



EFFICIENCY AND ENVIRONMENTAL IMPACT OF
FREE-RANGE EGG PRODUCTION: A MIXED-METHOD
CASE STUDY OF WALES

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Summary

The egg industry in Wales is an important component of the agricultural sector. According to the Welsh Government's Aggregate Agricultural Output and Income Statistics (2008, 2013), from 2006 until 2013, the value of egg production in Wales nearly doubled. The rising potential of egg production creates a need for research in the field of rural economic development and its inevitable environmental impact for the convergence area of Wales.

The objective of this study was to define the major environmental impacts of free-range egg producing farms as well as to lay out basic strategies for improving the efficiency of free-range, non-GM egg farms under investigation. The study adopted an interdisciplinary, mixed methods approach. Qualitative data from in-depth interview has been used to consider the feasibility of improvement in business processes and relationships to advance performance. SWOT analysis has been used in order to examine the internal and external environment of the businesses studied and Retrenchment and Renewal Strategies have been proposed with the intention of looking into a wide-range of short-term actions that could reduce financial losses, stabilise the performance of businesses studied and work against the problems that contributed to poorer performance. The use of production and management accounting data from the collaborating enterprises allowed to calculate performance expectations for free-range, non-GM egg farms in areas such as egg production and feed.

The results of this study indicated that there are various internal factors that influence the efficiency of the farms studied and all of them are directly or indirectly related to farmers' perceptions and motivations for running the business. Nevertheless, the external environment also has a great influence on the performance of the businesses, to the point that small and medium egg production could be perceived as a high-risk investment. In order to improve the efficiency of businesses studied this thesis proposed a list of recommendations that is believe to address all the issues related to egg farming which were raised during the research.

The supply chain involved a collaboration between producers – owners of small and medium size free-range, non-GM egg laying farms in Wales, two major companies – Wynnstay Group Plc, Stonegate, and various supermarkets.

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1. Introduction

The egg industry in Wales is an important component of the agricultural sector, and certainly demonstrates growing potential. According to the Welsh Government's Aggregate Agricultural Output and Income Statistics (2008, 2013), from 2006 until 2013, the value of egg production in Wales nearly doubled. Moreover, the number of chickens used for egg production, reported by June Survey of Agriculture and Horticulture, increased around 20% in the laying flock over the same period. Egg production in Wales has become much more important over the last years, as it is not only a specialised farming activity but there is also a profitable option for market diversification. The rising potential of egg production creates a need for research in the field of rural economic development and the inevitable environmental impact for Wales. This thesis will not only address these issues but also propose strategies for improving efficiency and reducing the environmental impact of egg production.

The understanding of sustainable egg production has dramatically changed over the past century. As with all agricultural sectors, an increase in demand for eggs in that period triggered the development of modern production practices. To meet the nutritional needs of bigger populations, using the same amount of land and fewer workers, new breeding, feeding and management methods were required. At the same time, science evolved. More was learned about food safety and food quality, as well as animal welfare. By that means, egg production moved from farmyards to highly automated barns. Nutritional values in poultry feed have become precisely measurable and aligned to hen body weight gain, which consequently resulted in increased feed efficiency. Thanks to modern prevention methods, the possibility of bacterial contamination has dramatically reduced and eggs produced in conventional cages are perceived to have the best quality from a microbiological point of view (Mench et al., 2011). Modernised practices have caused the egg production to become more sustainable and efficient, but not necessarily focused on reducing its environmental footprint.

One of the critical mechanisms of egg production is a well-managed supply chain. Production of eggs is a long and costly process starting from feed and animal suppliers, through farm, warehousing, storage and processing companies, then ultimately to retailers and the

customer. A good relationship between all of these elements is extremely important in order to manage the supply chain effectively. This thesis explores both business and sociological dimensions of a particular egg supply chain by evaluating its performance and exploring possible measures of improvement. The supply chain involves collaboration between producers - owners of small and medium sized free-range egg laying farms - and two major companies, Wynnstay plc and Stonegate, as well as various supermarkets. Wynnstay is a major supplier of agricultural inputs and a key component of the egg supply chain. Stonegate is an egg packer that collaborates with Wynnstay in organising a large number of free-range primary egg producers. At the end of the supply chain, there are various supermarkets that purchase regular, brown and speciality free-range eggs from Stonegate. This thesis will analyse the direct relationship between farmers and the three companies in order to find possible gaps and propose strategies to improve the collaborative processes.

Another important aspect of egg production is resource usage and emission of greenhouse gases to the environment. It is a trend and a global necessity that today's agriculture needs to produce more eggs using less resources. However, some authors believe that productivity should be increased in a more sustainable manner. The environment should be protected from degradation in order to not to bring disadvantage to future generations and management practices should be both socially acceptable and economically constructive (Toma et al., 2013). Egg production raises questions around the use of water and energy on a daily basis, the emission of carbon, the levels of waste produced and the use of fertilisers, as well as the associated production of nitrous oxide and methane.

The European Union (EU) puts a substantial emphasis on enforcing environmental and waste management laws and regulations. It requires every business to adapt equipment and procedures to meet imposed standards. Many businesses undertake stricter changes in an effort to preserve the environment and animal welfare. They take proactive environmental measures and attempt to re-coup the expenses through consumers who are willing to pay a premium for environmentally-friendly products. Failure to follow environmental law and regulations can result in increased pollution levels which have a negative impact on public health, safety and welfare. Compliance is strongly encouraged as environmental violations may lead to criminal penalties. On the other hand, an eco-friendly attitude can be also very profitable for the company. The reduction of physical waste, increased energy efficiency and

improved resource productivity inevitably lead to savings which improve profitability and enhance competitiveness. Environmental waste is the best proxy for identifying and eliminating economic waste (Zokaei, 2013). This thesis will therefore also address the issue of environmental pollution caused by egg production and propose methods for its reduction

Finally, the most important aspect and a core motive of this thesis will be to research on-farm processes and farm management. There are various factors that play an important role in the performance of an egg producing farm and all of them are directly, or indirectly, related to a farmer's perceptions and motivations for running the business. Good farm management can dramatically improve the efficiency of the farm and process control is vital in finding future improvements. Using tailored sociological methods, this thesis will examine farmers' opinions, their approach to the business and their relationships with other members of the supply chain.

1.1. Research Question and Objective

The objective of this study was to define the major environmental impacts of the free-range, non-GM egg supply chain under investigation, and demonstrate how a reduction in such environmental impacts can improve consumer appeal of products, enhance productivity and facilitate compliance with relevant statutory regulations. It also examined strategies for improving efficiency of egg production and assessed whether better supply chain management is possible, and if so, how this could be achieved. The aim was to attain a sustainable egg production process that would smoothly reconcile process efficiency, reduce environment contamination and increase the market value of the eggs.

The concept of an environmental footprint is strongly related to resource efficiency. According to The European Commission's Policy brief on Resource Efficiency, reducing one's environmental footprint impacts positively on resource efficiency (Jansen, 2013). That is why egg producers, together with other agricultural sectors, are increasingly required by both governments and consumers to identify environmental impacts and resource usage. In the egg supply chain this requires a focus on emissions of greenhouse gases (GHG); cumulative energy demands; water use and aquatic environments on the farm; the nutritional efficiency of feed conversion ratios; and management of solid manures. From a supply chain perspective, life cycle assessment (LCA) offers scope to provide a comprehensive evaluation

of resources at different stages, from input supply through to distribution and retailing. Alongside improved environmental and resource efficiency, significant production and organisational benefits can be achieved leading to greater overall value across the chain. However, due to the complexities involved, including the number of participants and the constant and dynamic evolution of food supply chains, considerable challenges needed to be tackled.

Factors affecting supply chain efficiency include:

- The quality of relationships (trust and commitment) and their management across the range of participants
- The alignment of purchases and sales through operations planning, quality and safety management
- The adoption or quality of commercial marketing strategies
- The use of new and emerging technologies to achieve competitive, sustainable and reliable deliveries to final consumers.

Major developments in food supply chains have occurred from the adoption of IT and performance-related communication systems and processes. Their adoption can also contribute to improved environmental performance.

The scope for the development of high quality and environmentally benign egg production will provide alternative opportunities for farmers either as a major enterprise or diversification strategy, improving farm profitability and generating additional labour demands in the open countryside. The thesis aims to provide increased expertise in the development and use of cross-supply chain data which will allow individual producers to benchmark and enhance performance. At an overall level, it will demonstrate the degree of comparative environmental pressure in relation to other protein products for marketing and promotional purposes.

1.2. Research Methods and Analysis

The study adopts an interdisciplinary, mixed methods approach. The use of production and management accounting data from the collaborating enterprises allows assessment and quantification of the portfolio of economic and environmental impacts. Secondary data is used to convert or develop proxies for such information into environmental and economic footprint representations. Qualitative data obtained from in-depth interviews is used to consider the potential for improving business processes and relationships to advance performance. The life-cycle analysis of emissions across the egg supply chain is undertaken with a view to improve environmental quality and identify the most cost-effective means of reducing carbon and other GHG emissions.

The study commences with an examination of trends and opportunities in the egg sector, in particular, the consideration of the role and contribution of primary producers in the overall egg value chain. An important focus of the thesis is to assess the economic and environmental footprint of the production, logistics and distribution organisations around these primary producers. This will require an examination of air, water and soil emissions, and solid wastes, taking into account environmental impacts embodied in inputs, as well as those which occur downstream in the supply chain. The analysis has been conducted mostly via secondary data but also in collaboration with the Wynnstay company partner whose associated businesses made appropriate data available. The partnership provided an opportunity to jointly identify and develop innovations in supply chain management, to improve the profitability and environmental impact of egg producing farms. It also allowed for the appropriate distribution and marketing of the resulting additional value generated, particularly those that derived from increased credence properties which appeal to final consumers.

2. Literature Review

The overall goal of this chapter is to establish the significance of egg production for the Welsh and British economies, and highlight the evidence of its influence on the environment. The literature on production-efficiency measurements is broad (e.g. Debreu (1951); Farrell (1957); Farrell and Fieldhouse (1962); Färe, Grosskopf, and Lovell (1985)), where both input-based and output-based efficiency measures have been used. Nevertheless, the approach is strictly measurable and numerical, with no consideration of sociological issues. Similarly, there is considerable literature available on the environmental impact of egg production around the world, in Europe, and more importantly, in Great Britain, however, through the exploration of the literature it has been found that little, if any, research has been conducted on smaller egg producing units such as those in Wales. Therefore, the academic impact in this area has been fairly limited. Still, given the growing potential for egg production, this is a need that would be advantageous to address, and there is, therefore, an opportunity for a more extensive socioeconomic study.

This thesis will contribute to an examination of efficiency strategies that could be applied in order to improve processes on small and medium free-range egg farms in Wales, and along the supply chain, whilst acknowledging and addressing the importance of environmental care. The bulk of this chapter is devoted to critically evaluating the different methodologies used in this field so as to identify the appropriate approach for investigating the research problem.

To begin with, it is essential to establish a definition of efficiency in egg production. According to Chavas et al., (1993) economic efficiency at the micro-level is composed of three sources - technical, allocative and scale efficiency - and focuses on the ability of businesses to use the best available technology and to allocate resources effectively. Therefore, technical efficiency in egg production would be attained when the best available technology is used. Allocative efficiency would hold when resource allocation decisions minimise costs and maximise revenue. So profit maximisation (taking market prices as given) and scale efficiency would be achieved when the business is of a sustainable size, i.e. when no industry reorganisation will improve output or earnings. In other words, efficient egg production is achieved when the egg is produced at its lowest average total cost without

losing its quality and nutritional value. This would include minimising waste, effective labour and animal management, good control of on-farm processes and improved capital equipment.

2.1. Agriculture in a Historical and Contemporary Perspective

The industrialisation of agriculture has been widely established for less than a century and arose with the need for cheaper food and farming for a greater scale. What was once produced in the backyard of a household, needed to evolve into a system that would feed the rapidly growing human population, which from 1950 to 2010, has almost tripled in size (United Nations, 2013). Many small farms and businesses transformed into global corporations, with the ability to manage complex supply chains, in order to meet the rising demand of society. However, many have not changed and are subsequently striving to compete with the global 'giants'. In the last fifty years, i.e. from 1960 to 2010, the global population has increased from 3 billion to 6.8 billion people. On 11 October 2012, the world's population was recorded at just over seven billion people and according to demographic forecasts, in 2025, the Earth will be inhabited by 7.9 billion people, and in 2050, 9.3 billion (United States Census Bureau, 2014). The demand for food is growing, but so does demand for its quality. Nowadays, producers need to not only ensure that they grow a sufficient amount of food, but also that the food is nutritious, complies with imposed rules and regulation, and is affordable and accessible to the population.

One of the European Union's key policies regulating agricultural activities is the Common Agricultural Policy (CAP). The original aim of this policy was to provide enough food, and produce high-quality goods in a sustainable manner, and to meet the requirements for environmental protection, public health, water resources and the health and well-being of animals and plants, which altogether, is believed to guarantee a stable agricultural income. It is also meant to serve purposes such as improving agricultural productivity and sustaining viable rural communities (CAP, 2014). However, there has been a lot of wide-ranging criticism published on CAP by many diverse interests since its inception. It has been accused of encouraging overproduction, which leads to unfair market competition for African and Asian countries, where producers simply cannot keep up with cheap competition from

Europe. Thus their incomes can no longer provide for their families (Matthews, 2012). Moreover, CAP traditionally provides better support for farmers who produce larger quantities, and therefore bigger farms have benefited from the receipt of subsidies much more than smaller farms. This puts small scale productions and family farms at a significant disadvantage (Euro Parliament, 2010).

The food industry sector is one of the largest and most important manufacturing sectors in Europe. It is the second largest manufacturing industry after metal, comprising 14.5% of total manufacturing turnover, totalling €917 billion for June 2013 (European Commission, 2014). According to the same source there are 500 million consumers in Europe and they should all be provided with a reliable supply of healthy and nutritious food at an affordable price. Kwasek (2012) states that in order to fulfil these expectations, the EU's agriculture will have to take more care of the environment, including land and water resources, biodiversity and climate change, as these factors strongly influence food production and prices. It is crucial to maintain the agricultural production capability of the EU at an efficient level, and at the same time, respect the obligations of the European Union arising from international trade agreements and policy for development, as a strong agricultural sector is necessary for a competitive food industry.

It is commonly known that eggs have been used as food by humans since early antiquity, but it is only in the last century that the potential use of eggs and their related products has been fully realised. This has resulted in maximisation of their production and quality (Romanoff, Romanoff, 1949). Industrialisation meant abandoning natural farming in favour of operations such as specialisation, simplification, mechanisation, standardisation and consolidation, which were intended to improve the food supply chain. Specialisation in the egg producing system is based on the idea that farms, and other operations, could function more efficiently by focusing on fewer tasks. This economises the investments and enables tasks to be performed more efficiently. The poultry supply chain, therefore, is separated into many distinct, specialised industries: growing feed crops, storing and transporting grain, feed processing, breeding pullets, raising broiler and layer chickens, laying eggs, transporting eggs, packaging and finally selling the products. As the work became simpler and more routine, this allowed for the mechanisation of systems or processes, which replaced human and animal labour with machinery and aided in routine tasks, but at the same time, it caused

production to be more dependent on resources manufactured off the farm, such as agricultural chemicals and fossil fuels (Kirschenmann, 2007). Monocultures led to a greater dependency on synthetic fertilisers and chemical pesticides. For example, in the USA, from 1948 to 2008, the use of agricultural chemicals increased more than five-fold (USDA, 2010). Hormones and antibiotics were introduced to speed the growth of food animals. Even though the new technologies made production more predictable, reliable and repetitive, these transitions were based on an assumption that cheap energy would always be available to fuel the system, and that technological innovation would always overcome production challenges. Nevertheless, this assumption was proven to fail over time, as the increasing demand for non-renewable resources started threatening to exhaust them (Tilton, 2003). The United Nations has become seriously concerned about the matter, and recently, the depletion of natural resources has begun to be a major focus of governments and organisations (Library Index, n.d.).

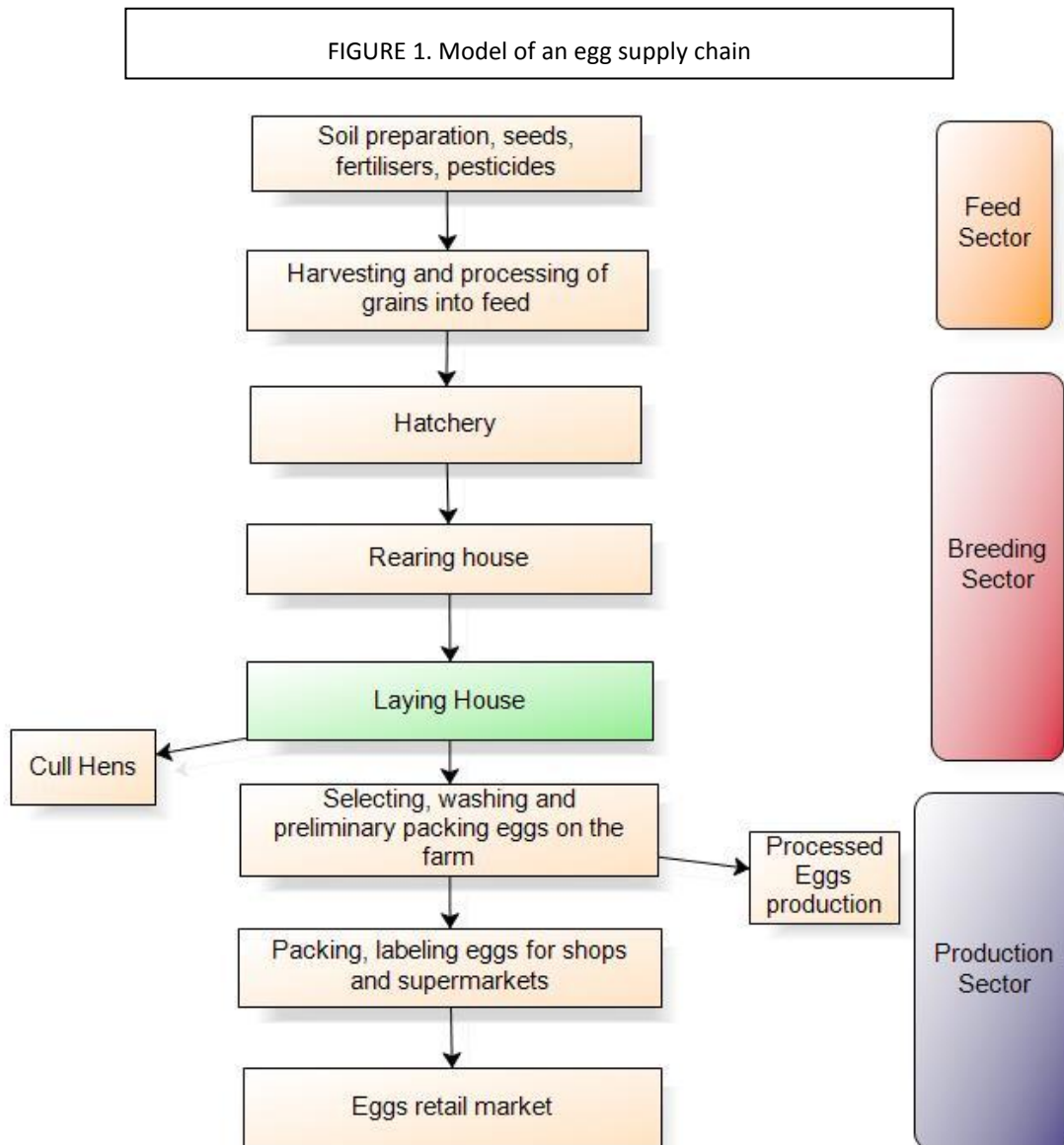
In *The End of Food* (2008), Paul Roberts investigates the modern food system and discusses that how we make, market, and transport our food is no longer compatible with the billions of consumers the system was built to serve. Moreover, the benefits of mass production have also incurred many costs, including the loss of natural resources, ecosystem degradation, rising rates of diet-related chronic disease and ongoing inequalities in access to food. Many authors speculate that the current period of fossil-fuel-derived abundance will not last long, calling attention to the question of where our food system is headed next. This expansion of consumption had profound environmental impacts. Xin et al. (2011) argue that one of the results of the expansion was that sustainability became a dominating global, social environmental and economic priority among governments, international organisations and the private sector. Therefore, leaders increasingly understand that making progress towards a more sustainable economy requires substantial reductions in resources used at a global level, as well as reducing GHG emissions in business activities.

2.2. Environmental Assessment of the Egg Supply Chain

Emissions that originate from egg production contribute to a wide range of environmental impacts, therefore, there is a clear need to provide complementary insights, in addition to regulatory practices, to help reduce such impacts. To evaluate the potential effects that egg

production has on the environment, the method used by the majority of researchers is Life Cycle Assessment (LCA). This comprehensive tool works throughout the entire life cycle of a product in order to calculate its overall environmental impacts. The life cycle is divided into stages which start from raw material extraction, materials processing, manufacture and distribution through use, repair and maintenance, and disposal or recycling. There are two main sub-sets of LCA: cradle to gate, which analyses the stages up to manufacture, and cradle to grave, which analyses the whole life cycle of a product (Williams et al., 2009). This work focuses on describing cradle to (packing) gate, and thus omits the final stages of consumption and disposal of residues by customers.

In order to assess any weak points of an egg supply chain, it is necessary to break down the whole system into small parts so that each part can be reviewed separately. Figure 1 shows a model of a basic egg supply chain in the UK market, divided into different production stages. It is important to mention that environmental impacts vary and are largely related to the efficiency of resource use by different egg production systems. As will be discussed further in this chapter, while taking into consideration direct and indirect impacts, there are three major energy, material and environmental burdens in egg production that need to be addressed: GHG emissions, waste and diffuse emissions, and use of energy. Water and electric energy use can be considered as less influential but equally significant. Emission of GHG occur in every stage of egg production, however the vast majority comes from soil and its fertilisation, storage of chicken manures, and emissions associated with transport from and to the packing station. On the other hand, waste that is produced in the Rearing and Laying House includes both solid and slurry manure, which are a source of volatile ammonia. Lastly, the energy, both fossil and electric is mainly used for day-to-day running of a farm/factory and transportation. Animal welfare is also very important and occasionally controversial issue when it comes to the egg producing business. Unfortunately, there is no method available for quantifying the lifetime stress of birds going through different systems that can be incorporated in LCA (Williams et al., 2009). A more detailed environmental impact assessment on free-range egg production in Wales will be presented in the next chapter.



LCA is an adequate tool to support decision making with regard to environmental issues, and hence identifies opportunities for pollution prevention and reduced resource consumption. On account of better understanding of human health with respect to the environmental impacts of products and processes, egg-producing businesses are able to make more informed decisions to minimise their effects on the environment. Since society has become concerned about the issue of environmental degradation and resource depletion, a company that produces environmentally friendly eggs has earned an extremely positive and intangible asset. The underlying idea is that every business should work towards a zero environmental footprint by conserving, restoring and replacing the natural resources used in operations. It is important to understand the strategies of supply chain partners. For instance, a supplier

may implement a strategy to grow, and begin to perform manufacturing functions that infringe on other supply chain member's markets. Understanding the incentives of suppliers, as well as customers, therefore provides a competitive advantage. In order to remain a powerful player in a supply chain, a company can no longer afford to focus on its own business or those of its competitors; it must understand supply chain member's businesses as if they were their own (Benge, 2014).

2.3. Environmental Impact of Egg Production

The UK's agricultural sector accounted for 49 Mt CO₂-e in 2009, which is around 9% of total UK GHG emissions (Defra, 2011)., and thus has a substantial responsibility for protecting the upper atmosphere from potential destructive effects. However, in comparison with other animal production sectors, egg production is considered relatively environmentally friendly (Leinonen and Kyriazakis, 2013). Nevertheless, there is always scope to minimise potential environmental impacts even further. As mentioned earlier, the best method of estimating environmental impact is the LCA, which has an holistic approach to analysing production systems. The primary environmental aspects that are relevant to poultry farming at present, are major greenhouse gases with global warming implications (including those embodied in feed); water and energy usage; and direct emissions of animal manures. Numerous gases contribute to the GHG effect, primarily water vapour (H₂O), carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), ozone (O₃) and a range of human-made halocarbons that exist in small amounts, albeit with high potency. Although the greenhouse effect is vital for life on Earth, an uneven concentration of these gases in the atmosphere may lead to its warming and detrimental changes in the climate result. With climate change, increased pressure will be placed on agricultural production systems, leading to instability in supply of commodities such as grain. Taken into account the subsequent ramifications of this, any contribution the industry can make to minimising greenhouse gas emissions is vital for its long term viability. Of all GHG emissions from the sector, nitrous oxide and methane are the major pollutants. In 2012, British agriculture accounted for 84% of nitrous oxide (N₂O) emissions, which classified it as the main source of contamination, although in 2013, the amount declined to 66%. Around 46% of emissions come from methane (CH₄) and only around 1% from carbon dioxide (CO₂) (GOV, 2013). N₂O is responsible for about 6% of global warming and its

agricultural emissions are mainly caused by the application of synthetic fertiliser to arable soils and from storing manures. It has been estimated that 90% of the N₂O emissions come from three sources: direct emissions from soils (42%), indirect emissions from soils (33%) and emissions from pasture range and paddock manures (15%). In comparison, methane is responsible for 24% of greenhouse emissions to date. Most of the methane produced by agriculture comes from the digestive processes of livestock. All on-farm CO₂ emissions come from energy usage. Emissions of all three greenhouse gases from agriculture have been in decline since 1990 and further decline is expected by 2020. From agriculture, nitrous oxide is the only emission to have fallen, with a reduction of 20%. This is attributed to better on-farm environmental management and introduction of stronger environmental policies. Table 1 shows the global warming potential of major greenhouse gases.

| TABLE 1. The global warming potential of major greenhouse gases ¹ | | | |
|--|------------------------------------|---|--|
| Greenhouse Gas | Lifetime in the atmosphere (years) | 100 years' global warming potential – IPCC 2007 | 100 years' global warming potential – DCCEE (2010) |
| Carbon Dioxide | Variable | 1 | 1 |
| Methane | 12 | 25 | 21 |
| Nitrous Oxide | 114 | 298 | 310 |

GHG Emission from Egg Production

In evaluating GHG emissions from egg production, the data varies slightly between different published studies. Sonesson et al., (2009), estimated it as 1.4 - 1.6 CO₂-e per kg of conventional produced eggs, and Cederberg et al., (2009) presented similar data. Both studies have been conducted in Sweden. On the other hand, Williams et al., (2006), in a British study, found that eggs produced in conventional cages (which are banned in EU) emit 5.2 CO₂-e per kg while those from conventional free-range production emit 6.2 CO₂-e per kg. The considerable difference in values estimated in the latter study may have been caused by several reasons. Firstly, the use efficiency of the nitrogen in the manure was assumed to be lower, which led to a smaller amount of mineral fertiliser being replaced and greater nitrogen losses causing emissions of nitrous oxide. Secondly, efficiency in feed production was also lower, which resulted in a higher environmental impact for the feed (Sonesson et al., 2009).

¹ DEFRA (2014) *Observatory monitoring framework*

Furthermore, Australian research suggests that eggs have the lowest carbon footprint of all the major protein foods (Farminguk, 2012). The greenhouse gas emissions from free-range egg production amounted to 1.6kg of carbon dioxide equivalence, including methane and nitrous oxide, per kg of eggs (Wiedemann and McGahan, 2011). The figure for cage eggs was 1.3kg. The conclusion drawn in the Australian research was that the larger carbon footprint of free-range birds was due to the fact that they used more feed per kilogram of eggs compared with cage birds. Even though eggs represent a relatively low-carbon supply of animal protein, their production is strongly dependent on cereals and soya, and these are associated with high emissions from industrial nitrogen production, transportation and changes in land-use. On the other hand, organic eggs are estimated to produce 1.2 CO₂-e per kg in the study of Carlsson and Uldal (2009), and 7.0 CO₂-e per kg by Williams et al., (2006). All data has been compared in Table 2.

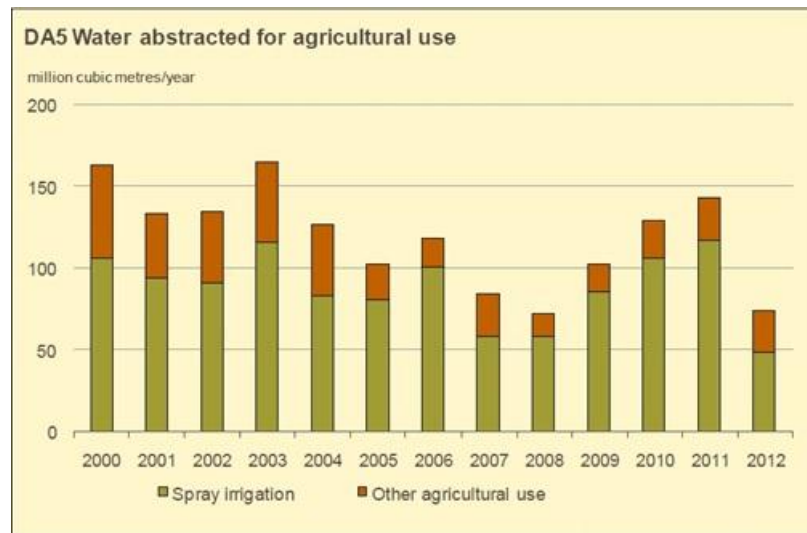
| TABLE 2. The greenhouse gas emissions from free-range egg production | | | | |
|--|-------------------------------------|-----------------|------------------|-----------------|
| | Co ₂ -equivalent/kg eggs | | | |
| | Total | CH ₄ | N ₂ O | CO ₂ |
| Sonesson et al., (2009) | 1.4 - 1.6 | 0.02 | 0.7 - 0.8 | 0.7 - 0.8 |
| Cederberg et al., (2009) | 1.4 | 0.05 | 0.8 | 0.55 |
| Carlsson et al., (2009) | 1.2 | 0.05 | 0.7 | 0.45 |
| Williams et al., (2006), conventional free-range | 6.2 | | | |
| Williams et al., (2006) 'organic' | 7.0 | | | |

Water Use

Just one standard shed of 16,000 birds for egg production can use two tonnes of water per day according to the Hy-line Commercial Management Guide (2013). Aggregating all the sheds in Wales would show a great amount of water being used by these animals every day. This quantity however seems to be of a minor significance given the recorded use of water in Welsh agriculture compared to other industries. Within as little as 0.3% of the total amount of agricultural water extraction in Wales and England, Welsh abstraction varied being less than 0.02% whereas that of English amounted for 1.68% (DEFRA, 2012). Moreover, in 2012 the agricultural water abstraction in both countries was 48% lower than in 2011, even

though the total amount of water in England and Wales abstracted for public supply and industries showed an increase of 20% on 2011 levels. Figure 2 shows water abstraction for agricultural use in UK.

FIGURE 2. Water abstract for agricultural use



Energy Use

Energy consumption for the agricultural sector is also relatively small compared with other sectors and it accounted for 0.6% of the UK's annual energy use in 2007 (DEFRA, 2007a). Within this 0.6%, electricity use for the sector amounted to around 56.5% of the total calorific value of energy, petroleum products to 8.3% and coal use dropped to zero (MacLeay et al., 2013).

Manure

During the storage of both solid and slurry manure, a very volatile ammonia (NH_3) is formed. This ammonia, when oxidised, contributes to nitrous oxide formation and affects nitrogen turnover in the ecosystem on which it is deposited (Sonesson, 2009). Estimated ammonia emission from poultry production for 2009 is 29,5 kt NH_3 which equals 13% of the total ammonia emissions in the UK (Misselbrook, 2009). Unlike in other types of animal manure the nitrogen in poultry manure is excreted in the form of uric acid, which is later converted to ammonium at varying rates depending on the storage conditions. In order to determine the

fraction of the total nitrogen, not only must the ammonium content be analysed, but also the content of nitrogen in the uric acid. Poultry manure consists of readily available nitrogen as well as a high phosphorus concentration, which makes it a valuable fertiliser. As egg production is often carried out in large units, the large amounts of manure generated per unit, requires farmers to dry it prior to transportation to arable farms. Dry manure can give better nitrogen use efficiency, with lower emissions of nitrous oxide and a lower mineral fertiliser requirement, and also, a lower amount of fuel is needed for its transportation. However, drying manure requires a large amount of energy which, if it is of fossil origin, may therefore raise GHG emissions.

Poultry farming in the UK is strongly controlled by very specific legislation and health regulations in order to maintain quality and to ensure that animal and consumer health is protected (Gov, 2012). UK egg-producing poultry farmers must follow national regulations for environmental protection and pollution control, and for the use of specific animal feed including medicated feeding products. These are strictly controlled for undesirable substances and permitted residue levels. The most well-known and respected guidelines are set out by The British Lion Quality Code of Practice, which is the only UK egg-specific assurance scheme that meets the stringent standards of the EN 45011 international accreditation standard.

In addition, the EU has imposed many regulations for poultry production, sale and disposal. In 2012, the European Commission officially implemented its ban on barren battery cages, replacing them with enriched cages, barns or other free-range systems. This procedure is believed to greatly improve the welfare of hens, but as battery cages were designed to provide maximum efficiency in egg production, replacing them meant reducing the volume of eggs produced using the same amount of resources. As a result, total egg production has been estimated to have fallen by 10 to 15% after 2012, which led to a substantial increase in egg prices (Thepoultrysite, 2012).

2.4. Analysis of Egg Production Systems

Hens are believed to be derived from Jungle Fowl, which means that the natural habitat of early hens was a tropical rainforest (Adler and Lawler, 2012). Jungle Fowl, to survive in the wild, would usually live in smaller group, build a nest for their eggs, forage for food and perch

at night. According to the BCSPCA (2009) the modern domestic strains, even though significantly different from their ancestors, still follow their behavioural patterns. They are likely to experience stress, as even one scared or nervous bird can initiate a fear reaction that spreads across the shed in seconds, and if repeated, may affect the well-being of hens and the egg laying process. The BCSPCA believes that the various types of housing systems used to raise egg-laying hens on farms, strongly impacts a bird's ability to perform natural behaviours, and therefore impacts on their welfare. There are four types of egg production systems: cage systems, which may take the form of conventional battery cages or enriched/modified/furnished cages, barn systems, free-run systems and non-cage or alternative systems that are divided into free-range and organic. Although the focus of this work is on free-range eggs, a brief description of other systems will be provided in order to compare their features.

2.4.1. Cage System

Battery Cages

This system houses egg-laying hens in small, barren cages that are stacked on top of each other. There is a limited space for each bird, and generally, three or more are kept in one cage. The supply of feed and water is automated through special units that provide adequate amounts according to the directions outlined for different types of flocks. The barn is closed, hence constant temperatures in the building are easy to maintain and the birds are not exposed to weather change. There is a broad consensus that the physical comfort, emotional well-being as well as the ability to perform natural behaviours is poor for birds in conventional battery cages. Studies show that hens in battery cages are more likely to suffer pain due to weak bones and injuries. The former is caused by a lack of movement which makes hens susceptible to bone fractures upon catching as well as during transportation. The latter is caused by standing constantly on the wire floors of the cages and may be associated with experiencing chronic pain. Moreover, research suggests that hens in conventional cages experience frustration due to severely restricted freedom of movement and their inability to nest while laying an egg, grooming, wing-flapping, perching and nest building. They become aggressive and start feather-pecking each other. However, they are less likely to experience fear due to the small, stable groups they exist within, and predation is not an issue.

This system is the most efficient of all. It has been designed to maximise egg production and minimise the costs of maintaining the animals. However, this all comes at the expense of the welfare of those animals, and subsequently it remains a very controversial topic.

2.4.2. Alternative Systems

Enriched cages

These systems are different to the conventional cages in that they do provide additional space per hen and increased resources that enable hens to perform natural behaviours. Access to feed and water appears similar to that in conventional cages, although it is recommended that feed should be provided in ground form rather than pelleted form, in order to encourage food-directed pecking behaviour and to decrease the likelihood of feather-pecking. The enriched cage still restricts a hen's ability to roam freely, but depending on the space provided per bird, they will be able to flap their wings and preen. The flooring can be litter rather than wire, which will prevent the birds from suffering from foot injuries. If the enriched cage contains insufficient nest boxes, the birds will feel frustrated at the time of egg-laying.

Barn egg production

Barn egg production is the best example of a free-run system where hens are able to move freely around the house, however, they are not given any outdoor access (Egginfo, 2014). This system provides more space than conventional battery cages, and is required to provide resources such as nest boxes and perches or a substrate for dust-bathing.

Free-range egg production

In the free-range system, birds range freely for food, rather than being confined in an enclosure. The EU egg marketing legislation stipulates that in free-range egg production, hens must have continuous daytime access to runs, which are mainly covered with vegetation (Egginfo, 2014). There are two different styles of housing free-range hens: the single-tier system and the multi-tier system. The ability to access outside areas has advantages and disadvantages. On the one hand, hens are free to perform their natural behaviours which greatly benefits their well-being. On the other hand, the thermal comfort of hens in free-range systems will be variable, since controlling temperature in an open building is much more difficult. This will increase the feed and water intake, as animals will

need more energy to keep themselves warm. Therefore, not only are the Feed Conversion Ratios (FCR) higher for free-range birds but also this system uses around 20% more energy than other methods of production (Thepoultrysite, 2013). Also, outdoor access means that birds must be protected from external threats such as predators. Foxes or birds of prey can be a cause of substantial losses. Alternative systems are believed to greatly increase hens' welfare, however, given their complexity, can be more challenging to manage and may require superior husbandry skills and knowledge. Feeding birds in alternative systems is generally regarded as more difficult than feeding birds in caged systems. This is primarily due to bigger competition between birds for feeder space, and greater fluctuations in house temperature (DEFRA, 2001). Also, laying hens must be genetically suited to the alternative housing system to realise its full welfare advantages.

Organic

The UK house conditions for organic hens are set by EU Organic Regulations. Hens producing organic eggs are always free-range. They must be fed an organically produced diet and ranged on organic land. The maintenance of these birds is much more expensive, but their eggs are becoming increasingly desired by customers.

To conclude, studies suggest that the nutritional content of eggs from hens that forage daily on a grass range is superior to that of eggs produced by conventional means. These studies report higher levels of omega 3 and vitamins, and lower levels of total fat, saturated fat, cholesterol and omega 6 (Long , 2007). Another study conducted by the United States Department of Agriculture (2010), determined that there are no nutritional benefits, differences in shell strength, the height of egg whites or the protein and crude fat content of free-range eggs when compared to caged eggs. However, the study did not measure the types of fat in the eggs, nor did it measure differences in vitamins and essential fatty acid content.

2.5. Ethics and Value Conflict

The ongoing process of industrialisation not only brought technological innovation and economic development, but is among the revolutions that have socially transformed nations through food (Teaching the Food System, 2014). In modern times, consumer decisions are

based on the consideration of many more aspects than just the taste of the product. Society has become concerned about environmental degradation and ethical issues surrounding animal welfare, and so this has become an integrated part of food quality. Many businesses have responded to this by providing “greener” products and making sure that their processes correspond with the protection of animal welfare. Nevertheless, customers are convinced that the situation is still far from being perfect, and their opinions have been analysed in the European Commission’s Eurobarometer study (2005).

According to the study, 75% of the UK’s population pays attention to the type of system in which eggs are produced. In comparison, in Slovakia and Spain, more than 50% of the respondents, before purchase, claimed that they would not consider or are simply unaware of, the system in which eggs were being produced (Eurobarometer, 2005). The same study shows that the labelling system in the UK is considered fairly informative and helpful in identifying whether the eggs were sourced from animal-friendly production systems. Answering the same question, Slovaks and Spaniards, again, classed their countries on the lower positions in the table, stating that they are very rarely or never able to identify in which system the eggs were produced. It seems that the worse the labelling system in a country, the more ignorant customers are in their product choices. This suggests that those customers that do not pay attention to product quality may be simply unaware of the choices that were available. In fact, 20% of the UK’s respondents did not know or did not pay attention to the type of system in which eggs were being produced. Following the previous conclusion, 20% could be targeted and educated in order to encourage them to make an informed choice in the future.

The opinion and perceptions concerning animal welfare may be influenced by a variety of factors (Swanson, 2000a). Culture, economics, scientific knowledge, religious and philosophical beliefs, and the visual attractiveness of the animal, can play a role in forming points of view. The contemporary opinion about the welfare of laying hens is indubitably bad. As many as 44% of Europeans are convinced that laying hens are the farm animals with the poorest level of welfare and protection. The percentage significantly increases in the UK, where 59% of British people stated that this level is fairly bad or very bad. Recent leaks to the internet, and other media, report some rather inhumane conditions within which laying hens were being kept for production, and furthermore, that poultry welfare campaigns were a

shock to the audience who were not expecting the living conditions of those animals to be so distinct from their natural environment (Gray, 2010; Murray, 2007). As a result, 62% of British respondents claimed that current UK food and agricultural policy does not give animal welfare enough importance. Clearly, the living conditions of laying hens in intensive production will vary to those on domestic farms, not least because of the nature of the production. Nevertheless, consumers retain confidence that farmers will make responsible decisions concerning the welfare of their animals, and that they regard the humane treatment of farm animals as important (Swanson, 2000b). Therefore, it is the industry's responsibility to consumers to make carefully researched decisions that would allow for the improvement and maintenance of the welfare of laying hens living in intensive production conditions. Likewise, a basic understanding of how animal welfare concerns arise, and are manifested in our society, is important when charting courses for future poultry production practices.

As a result, the vast majority of the UK's population, 61%, seem more likely to buy eggs produced in free-range or outdoor systems and further growth in the popularity of this type of production is expected in 2014 (Ranger, 2014). Only 7% of UK respondents claimed to buy battery cage eggs and 5% buy barn eggs. The matter is of high importance, because as many as 77% of British people believe that buying animal-friendly products could have a positive impact on the welfare and protection of farm animals. Those that are aware of animal welfare issues are willing to pay a premium in order to receive a better quality product. 65% of respondents would be willing to pay an additional 5% to 25% for eggs sourced from an animal-friendly production system.

Studies argue that what is available to consumers is designed and constrained by actors in the production chain, distribution, and exchange process, who bring products to retail. Critics say that label definitions can be misleading, deceptive and are designed to allow intensive production that would not meet the conditions most consumers would expect of free-range (Parker, 2013). Many companies tend to inform the customers only about those aspects that they would like them to know, and as long as customers are happy with their answers, they will continue to purchase the products. The image of traditional "happy" hens ranging freely on the field in search for worms, is an image that most customers associate egg production with. It is not necessarily authentic, but no company will try to disturb it,

rather they will use it for brand visibility purposes. Companies tend to play on the customer's unawareness, however, giving consumers access to the right information will allow them to make more informed choices and help drive animal welfare policies forward. Informed consumers are empowered consumers whose choices will be the motor of economic evolution.

2.6. Supply Chain Analysis for Free-range Egg Production

Based on Figure 1, the commercial layer industry structure can be divided into feed sector, breeding sector and production sector.

2.6.1. Feed Sector

Feed represents the major cost of poultry production, consisting of up to 70% of the total (Ravindran, 2013). Poultry diets are formulated from a combination of ingredients, but the basis of most poultry feed consists of cereal grains, soya and legumes, with soya making up between 20 and 25%. The rest of the ingredients include cereal by-products, fats, plant protein sources, vitamin and mineral supplements, crystalline amino acids and feed additives. Of total feed cost, around 95% is used to meet energy and protein requirements, 3 to 4% for major mineral, trace mineral and vitamin requirements, and 1 to 2% for miscellaneous feed additives as percentages or units per kilogram of diet (Ravindran, 2013). Feed composition is assembled taking into consideration the nutrient contents of the ingredients as well as their unit prices. Diet can exert a profound influence on bird welfare and performance, and therefore it is essential that the quality of the feed is good. Taking into account the UK's free-range egg market, there is a high demand for eggs produced by animals fed on a non-Genetically Modified (NGM) diet. Waitrose, one of the major supermarkets in UK (which collaborates with Wynnstay) claims that they intend to stay as GM free as they can for as long as they can because they firmly believe this is what their customers want (Waitrose, 2014). According to Valletta (2010), the sensitivity towards food issues has greatly increased in the EU over the past few decades. Moreover, the EU is argued to have the most stringent Genetically Modified Organisms (GMO) regulations in the world (Davison, 2009).

According to some studies (Non GMO Project, 2014), GMOs are a direct extension of chemical agriculture, and are developed and sold by the world's biggest chemical companies.

Despite the fact that the long-term impacts of GMOs are unknown, once released into the environment, they cannot be recalled. In recent years, most soya used for poultry feed production in the US and Brazil is GMO. Since soya is regarded to be an excellent feed ingredient for poultry, the poultry industry has little interest in finding alternatives, and therefore there has not been a lot of work in sourcing other ingredients that may be adequate substitutes for GMO soya (Hermes, 2010). GM-free soya is becoming increasingly difficult, and therefore, increasingly expensive, to source.

2.6.2. Breeding Sector

According to an independent consultant, in the UK, there are six hatcheries owned by five companies producing nearly all the approximately thirty two million female layer chicks (sixty four million including males) hatched annually (Defra, 2006). One hatchery which belongs to a breeding company, and hatches for two other companies, produces 22.5 million layer chicks per year, which is approximately 70% of UK production. There are also 275 specialist rearing farms in the UK registered with the British Egg Industry Council (BEIC), rearing more than the 85% of layers carrying the Lion Mark. The UK breeding companies are essentially franchisees of international breeding companies.

There are well in excess of hundreds of breeds of laying hens, and different breeds will have different characteristics. It depends on the breed as to whether the hens will be nervous or quiet, how many eggs they will lay, and how much feed and water they will need. Light breeds are usually more nervous, and possibly more flighty, than heavy breeds, but they tend to consume less food for the eggs they produce (The Poultry Club of Great Britain, 2014).

2.6.3. Production Sector

The UK is the sixth largest egg producer in the EU and it is 82% self-sufficient in eggs and egg products (CICEI, 2014). There are 865 farms registered with the BEIC to carry the Lion Mark (2006). Their size ranges from under five thousand to one million four hundred thousand birds. The UK table egg industry is assessed to be worth £561 million. In 2010, the volume of egg production for human consumption was 826 million dozen from the following farming methods: 50% cages; 42% free-range and 8.3% barn and organic (CICEI, 2014). Eggs are mostly sold by packing stations to major retailers, but a minority, particularly free-range and

organic, still have egg rounds that involve delivering to local shops and individual consumers or selling directly to the consumer from the farm.

There are over twenty major retailers in UK that sell free-range eggs. The marketing of eggs varies in each supermarket, as some supermarkets, such as Waitrose, offer not only organic eggs but also GM-free. At the moment, the retail price for a six pack of free-range medium eggs ranges between £1.38 and £2.15 (Ranger, 2014).

2.7. Reducing Environmental Impact

There is considerable literature available on improving efficiency and reducing the environmental impact of egg production. As mentioned earlier, these two aspects are strongly related. Improving the efficiency of egg production is concerned with achieving the optimal combinations of inputs for goods and services to receive maximum output for the minimum cost. Advancing environmental performance will, in the long run, result in better resource management, which will significantly improve the production efficiency. Moreover, the environmental performance of products and processes has become a key issue for many companies. Today's customers pay increasing attention to the environmental performance of products and processes of a company, and many consider animal welfare as a product aspect that helps inform decisions about a potential purchase. An optimal balance between a company's agriculture production efficiency and environmental performance will result in sustainable agricultural development. According to a UN Food and Agriculture Organisation report released in 2013, GHG emissions from egg production decreased by 71% since 1960 (Environmental Leader, 2013), nevertheless, there is always a scope for additional improvement.

The efficiency of egg production can be analysed in the context of agriculture, packaging, processing, retail and consumer processes. Each of these aspects creates a link in the supply chain. Amongst the problems that the current egg industry is facing, is the need to reduce GHG emissions, animal welfare and public opinion, nutritional and economic efficiency of feed conversion ratios and management of solid manures. According to WRAP (The Poultry Site, 2013), feed, its production, processing and refinement, accounts for more than half of lifecycle GHG emissions. Improving feed efficiency involves many different facets. In the majority of controlled experiments, a significant improvement in feed efficiency, at

unchanged or enhanced egg production, was obtained when layer diets were supplemented with phytogenics (Steiner, 2014), a group of natural, non-antibiotic growth promoters (NGPs) used as feed additives. An improvement in egg shell quality and breaking strength was also reported. Eggs had an extended shelf-life (increased oxidative stability), which would be perceived as beneficial by the processing industry. Moreover, feed efficiency can be improved through genetic selection of laying hens, as some breeds have genetic potential for producing more, better quality eggs at a lower feed intake (Christensen, 2013). Additionally, improved feed efficiency means fewer environmental concerns about chicken manure, which is often used as a fertiliser. The environmental impacts of egg production are largely related to the efficiency of resource use of each housing system. According to Leinonen's (2013) study of egg production, due to a longer production cycle, higher feed consumption and manure production, the alternative systems were less efficient than the cage system, and therefore also had higher environmental impacts.

The fact that the world's egg-eating population is growing has encouraged the industry to farm hens with higher production efficiency. Eurobarometer study (2005) concluded that the expansion of all intensive egg production systems had a significant and negative impact on the quality of water, air and landscape. The amount of poultry increased between 1990 and 2004, and the mass production of eggs limited animal welfare to a minimum. National and multi-national retailers are playing a major role in developing and enforcing animal welfare standards, nevertheless, their actions are based on customers' opinions and preferences. Eurobarometer (2005) surveys showed that animal welfare is a core value for European consumers, justifying the EU legislative ban on conventional cage systems in 2012. Nonetheless, future solutions to welfare issues have to involve, not only an understanding of social perceptions and expectations of how to treat animals and control quality and production, but also will require the scientific development of measurements for hen well-being (Swanson, 2000). Moreover, based on animal welfare concerns, egg producers are being pressured from many directions to change the way in which they house hens. The discussion about advantages and disadvantages of different housing systems is still open to research, but from what has been established already, it is known that production in enriched cages would increase the cost of eggs by only about 1 penny per egg. In non-cage systems, costs are higher and overall production per farm decreases.

The literature review has shown that eggs are a valuable source of nutrients for our

population. Over the years, the egg industry required a major reformation to transform from household farming into large-scale farming and be able to continuously supplying the products to a growing number of people. In addition, nowadays, egg farms in Wales, in order to produce eggs, have to comply with many rules and regulations which aim to control food hygiene and reduce the environmental impact of egg production.

2.8. Qualitative Research on Poultry Farm Management

In addition to the environmental dimension of poultry farming, this thesis explores the principal factors determining the efficiency of free-range poultry farm management. Over the history of farm management, a number of reviews have been carried out. Early reviews in the 1950's and 1960's focused on production economics and mathematical programming (Jensen, 1977; Malcolm, 1990). In the late 1960's, after studying the contributions that various disciplines made to farm management research, Johnson (1957) stated that economics provide a necessary, but not sufficient framework for the study of management in farming. Hence, the research focus moved towards the decision-making processes used by farmers (see Johnson, 1957, 1963; Plaxico and Wiegman, 1957; Williams, 1957; Burns, 1973; Jackson, 1975; Andison, 1989; Howard and MacMillan, 1991; Rougoor et al., 1998; Nuthall, 1999). During that time, the emphasis was put on quantitative research involving survey-based, cross-sectional research approaches (Howard and MacMillan, 1991; Rougoor et al., 1998). In the 1990's, a criticism identified by Howard and MacMillan (1991) stated that the studies undertaken in the 1980's failed to investigate the means by which farmers achieved high levels of performance. A similar critique has been applied to many others studies which started to investigate the relationship between farm, farmer characteristics and farm performance (Rosenberg and Cowen, 1990; Tarabla and Dodd, 1990; Cruise and Lyson, 1991; Wadsworth and Bravo-Ureta, 1992; Jordan and Fourdraine, 1993; Jose and Crumly, 1993; Boland and Patrick, 1994; McGregor et al., 1995). As a result, there has been a shift in emphasis away from quantitative surveys to qualitative case studies which allow for better identification of management processes.

In 2009, Gray stated in his work 'Farm Management Research: a Discussion of Some of the Important Issues', that the existing research on farm management that puts the emphasis on quantitative research methods, and those which adopt economics and mathematical modelling as the underlying theoretical framework, tend to ignore the presence and the

effect of the farmer in farm management. This focuses research on the criteria by which a decision is made (Gasson, 1973) rather than the aspects which influence the process of making the decision (Andison, 1989). It is believed that case study methods provide a better understanding of farmers, and the complex processes used by them, than traditional quantitative research approaches, and therefore reflect well the practical sides of the business (Mintzberg, 1975, 1979; Morgan and Smircich, 1980; Yin, 1984).

The farm management theory diverges into three different views of management practice: management, decision-making, and problem-solving (Scoullar, 1975). According to Seo (2007), all of these processes, especially decision-making, can be affected by emotions and feelings that accompany people at particular times. He believes that feelings are an indispensable part of people's individual and organisational lives, and they have power to both benefit and harm choices and decisions made by individuals.

Feelings and finance are also closely related. Investors are frequently instructed to avoid or suppress strong feelings before making any decisions (Babin & Donovan, 2000). Nevertheless, despite the commonly-held belief that feelings can negatively impact upon decision-making performance, Seo's research found that individuals who experienced intense feelings had better results in decision-making performance.

Communication, and how this impacts upon trust, is another important aspect affecting farm management processes and supply-chain relationships. Maggiani (2014) stated that communication is vital to the success of a business, and the most effective communication is when it enriches all stakeholders. Poor communication between businesses is a cause of lower efficiency; it impacts upon the motivation of the employees and may be a source of confusion and lack of trust (Writing, 2014). Moreover, in a complex and competitive business climate, communication is believed to be a key element of success and long-term profitability (PMI's Pulse of the Profession, 2014). On the other hand, the Economist Intelligence Unit (2008) conducted a survey that proves that good collaboration between companies is based on trust. They stated that a rigorous approach to establishing trust as a critical capability in collaboration enables companies to reap the full benefits of the environment.

2.9. Summary

To conclude, free-range egg systems generate more environmental pollution than cage systems due to greater consumption of feed while cage systems maximise egg production,

but at the expense of animal welfare. The value conflict which raised due to this matter resulted in 61% of British customers being more likely to purchase free-range eggs giving a scope for free-range egg farming market to grow.

3. Methodology

This chapter discusses in detail the research methodology that has been adopted in the study. The literature review suggests that there is wide academic interest in the egg industry around the world, and topics such as environmental pollution, feed efficiency and animal welfare for various egg production systems have been of major concern. However, the research has mostly concentrated on larger scale farming and adopted a strong quantitative approach. Little, if any, qualitative research is available on poultry farming, which addresses important issues from a perspective other than the strictly numerical.

Wales prospers with agricultural land that encourages more and more farmers to start their own, family-run or private egg-laying poultry farm. Yet, there is very little academic research that that works to support small-scale farmers. This thesis, therefore, addresses the issues of efficiency for small and medium free-range egg poultry farms in Wales with a particular attention to its environmental footprint. It was believed that the best manner to approach the socio-economic problems of the sample studied was by applying a mixed methods approach whilst maintaining a significant focus on qualitative research. In order to achieve that aim, a number of owners of free-range egg-laying poultry farms in Wales have participated in an interview for the study. Their valuable contribution has been considered very helpful to the project in order to arrive at the findings that will closely examine the efficiency of farm production and its potential impact on the environment. Their point of view was intended to assist in assessing the integration of business processes throughout the supply chain, and to create a general idea about their upstream and downstream relationships.

Basic statistical and advanced analytical tools have been employed to evaluate farmers' professional insights and opinions about farm production efficiency, as well as to determine the level of confidence that farmers have in Wynnstay and other companies. The key area of the research was to evaluate the efficiency of existing farm management strategies, trace the

environmental footprint of production processes, examine the factors that motivate farmers to undertake environmentally-friendly actions and assess whether or not they consider it an important aspect of their business. Since the research explored some delicate issues, and required farmers to provide the researcher with private information, the study adopted an attitude of trust and each respondent was assured of their privileges and anonymity. The study was carried out in co-operation with Wynnstay plc.

3.1. Research Design

This study adopted a mixed methods approach, integrating the use of both quantitative and qualitative methods. Quantitative methods allow for statistical analysis and benchmarking whilst qualitative methods allow for evaluation of perceptions impacting on decision-making processes. According to Mack et al., (2011) the main advantage of qualitative methods is their ability to provide complex textual descriptions of information about the personal dimension of an issue. They enable examination of the relationships, beliefs, opinions, emotions or potential contradictory behaviours of an individual. Many of the farm production systems cannot be meaningfully understood without direct, qualitative reference to the context in which farmers operate. Therefore, integrating qualitative and quantitative approaches in the analysis provides insights that neither approach would generate on its own. To achieve the research objectives, this research employed a comparative case study design to allow analysis of a small number of small to medium-sized poultry enterprises in different contexts. This method made it possible to generate a large number of variables in a small amount of cases. Moreover, the use of a simple business simulation model provided a basis for creating a practical management tool to help farmers run their businesses more efficiently. This model would be advantageous in the instance that further developments of the project are considered in the future.

The farmers included in the study, when compared, offered a source of analysis in identifying potential differences between their motives and perceptions for management, production methods and preservation of the environment. After obtaining interview responses from each of the farmers involved in this research, the study uses content analysis to examine the interview responses for production efficiency on each farm, and the level of trust and co-operation upstream and downstream of the supply chain. The interview responses were

compared and contrasted in order to find similarities and differences in farmers' opinions. Special emphasis has been placed on how the interview responses varied with regards to strategies of farming methods and to the attributes of innovation. Through this process of farmer identification, interviewing and response analysis, the researcher identified the motivation, personal situation and perceptual differences between farmers of differing farm sizes with regards to their farm efficiency and environmental awareness. Moreover, the situation on each farm has also been subjected to observation in order to compare farmers' perceptions with the actual state of the processes. Farms differed in their size, productivity, income generated, housing method and level of mechanisation.

The data analysis has been performed as follows. Qualitative data from in-depth interviews has been used to consider the feasibility of innovations in business processes and relationships in order to improve performance. Quantitative data have been presented in the form of cost implications of underperformance in areas such as egg production and feed. Financial implications for 5% under or 5% over the expected performance have been calculated using the breed standard data and available information from Wynnstay. This have been used to indicate the cost implications to farmers if they do not meet expected benchmarks for free-range, non-GM egg producers. Secondary data from the environmental footprint of free-range egg production, and existing management tools, has been used to convert or develop proxies for such information. An appropriate marketing strategy has been developed which takes into account the additional value generated from free-range and GM-free poultry farming, strengthening the position of these eggs on the market.

3.2. Data sources

Data was collected by three means:

- Obtained as secondary data, from a literature review and extensive reading on previously conducted research in the same or similar field.
- Obtained as secondary data, from the collaborating enterprises.
- Obtained as primary data, from in-depth and semi-structured interviews with farmers.

It is important to note that the researcher intended to gather as much quantitative data about the farms studied as possible. Unfortunately, it was not possible to obtain economic data on manure produced, labour costs, recent investments and hen production costs for each farm. Furthermore, data on feed costs, annual egg production, costs per pullet and mortality rates for each farm were not complete, and hence were considered not representative for the study and excluded from the analysis. This limitation to the study will be further discussed in section '6.2 Limitation of the Study'.

3.3. Research Location

Research was conducted in the area of Wales, in co-operation with Wynnstay Group Plc headquartered in Llansantffraid. On the map below the area of study has been circled in red.



3.4. Data Collection Techniques

The secondary quantitative data has been gathered in two ways. The literature review and extensive reading of existing research into free-range poultry farming allowed the researcher to gather some of the essential quantitative data, which owing to the very limited timeframe of this study, would not have been possible otherwise. The rest of the secondary quantitative data has been gathered only through the willingness of collaborating enterprises, therefore the research has had to be limited to only the data that was possible to acquire. Where available, the following data has been acquired from the interviewed enterprises: production accounting data and general management information.

In addition, data has been collected by conducting semi-structured interviews with ten poultry farmers located in Wales and one Wynnstay company representative. It was decided that the semi-structured interviewing methods would be most effective for this research for a variety of reasons. Firstly, these interviews provided the respondent with the opportunity to take control, to define opinions and to direct the interview towards areas which they see as interesting and significant. This allows new and important insights to be obtained by the researcher. Secondly, less structured and in-depth interviews allow for increased exploration and therefore a better understanding of the responses. The semi-structured interviewing method is more likely to provide valid data by giving the interviewer a better chance to pursue a topic, to explore any further or arising questions, and ask the respondent to qualify and develop their answers. Also, the disadvantages of this method have been acknowledged and appropriate steps taken in order to improve the interviewing experience. Firstly, because the sample size for the interviews was small, it may not have been representative of a particular population, nevertheless it has provided enough data to detect and explore key issues. Semi-structured interviews can develop in all sorts of directions and this may make comparison between data from different interviews difficult. For this reason, the interviewer has set out to conduct the interview according to previously prepared themes. Lastly, people like to present themselves in a favourable light. Respondents tend to be open about and even exaggerate aspects of their behaviour which they see as socially desirable, and to conceal or minimise aspects seen as undesirable. In case of such situation, the researcher's insight has been valuable in order to recognise and minimise any possible misleading.

3.5. Sampling Techniques

This research employed various sampling techniques. A purposive sampling method was used for qualitative data. The objective of the thesis was to focus the study specifically on free-range, mostly non-GM egg farms. In co-operation with Wynnstay, ten owners of free-range egg-producing poultry farms were identified, contacted and interviewed. The farmers were selected on the basis of farm size/type and farming experience. The group of farmers owning small to medium-sized egg farms were expected to appropriately match the objectives of this thesis nonetheless, in order to maintain diversity of the sample the farm sizes ranged from a smaller mobile shed farm to a bigger multi-shed and multi-tier farms. As the research progressed, it has been decided that one GM egg farmer will be included in the study in order to provide opportunity for economic and operational comparison of GM and non-GM farms. The data was generated in three forms: recorded and transcribed interviews with farmers as well as field notes and observation obtained during farm visits and unscripted conversations.

It is important to note that the researcher did not select the farms studied personally. The farms were chosen and contacted by the collaborating business on the basis of conditions agreed in advance with the researcher; such as diversity in sizes, egg types, shed types etc. An aspect that the researcher was unable to control was the already existing relationship status between Wynnstay and the farms appointed. Therefore, a possible bias would need to be taken into consideration bearing in mind that only 'well collaborating' farms could have been chosen to be contacted by the researcher.

3.6. Interview Format

As already mentioned, ten semi-structured, informal interviews were carried out with farmers regarding their perceptions of poultry farming and efficiency. Farmers were encouraged to express their opinions and feelings about any matter that seemed important to them. A member of Wynnstay was present during all interviews and could actively take part in the discussion. The purpose was to explore the subjects' opinions about various aspects associated with managing a poultry farm. By the end of the research phase, an additional interview with the feed company representative was carried out to support the

research findings. Topics discussed during the interviews were semi-structured around the following seven themes:

- 1) Motivation and incentives for engaging in a free-range egg producing business.
- 2) Nature and characteristics of free-range egg producing businesses.
- 3) Strategies and methods of farm management.
- 4) Environmental and animal welfare awareness in farm management.
- 5) Potential scope for efficiency improvement.
- 6) Farmers' perceptions about free-range eggs marketing.

3.7. Analysis Methods

All cases were compared and analysed using NVIVO, a qualitative research software, by taking into consideration the similar, divergent and contradictory behaviours, beliefs, opinions, emotions and relationships of individuals. Audio recording and transcription allowed the identification of interesting and novel issues which may overlap in different interviews. The use of software enabled the investigator to identify and categorise those themes. Each interview transcription was examined as follows. Farmers' comments regarding free-range poultry farming were extracted, summarised and compared across other farmers' answers. The interview questions were asked in a manner that emphasised the importance of farmers' own knowledge and experience in running the farm. Therefore, the answers were expected to point out their perceptions, motivations, farming and economy-based opinions, which altogether effectively created an image of the efficiency strategies that they undertook. The identification of farmers' ideas and actions led to recognition of the scope for feasible help and improvement. An example of software analysis has been provided in Appendix B.

3.8. Definitions of Key Terms, Concepts and Variables

It is necessary to explain what is meant by the terms 'production efficiency' and 'environmental footprint'. Since feed is, economically, the most important cost of egg production, some instances of the term 'production efficiency' may only refer to high production combined with relatively low feed intake (Rauwa et al., 1998). However, for this research, the definition will be extended. 'Production efficiency' will refer to the overall economic performance of the business, and it should be achieved by using best-practice

technological and managerial processes. The term 'environmental footprint' (Pef World Forum, 2014), on the other hand, will relate to the definition of Product Environmental Footprint and will denote not only the various, aggregated environmental impacts of systems, but it will also measure the absolute environmental impacts over the life cycle of eggs and egg-related service. 'Life cycle' in this context refers to almost all value chain stages for egg production, excluding product disposal.

3.9. Ethical Considerations

Ethical aspects of the study have been addressed by implementing the following measures. Respondents were briefed in relation to the aims and objectives of the study before the primary data collection process. No private or personal questions were asked from respondents. An open-ended pilot interview was conducted in order to practice and to clarify the researcher's understanding of the experimental situation, to generate new insights and hypotheses and to provide an opportunity for debriefing.

3.10. Work Experience and Pilot Case

In order to learn more about free-range egg farming, the researcher spent three days working on a free-range poultry farm in Newport, South Wales. During that time, the researcher participated in all day-to-day routines involved in managing a poultry shed, as well as taking part in the quality testing and packaging of eggs to be delivered to supermarkets. This experience was not only enriching, but provided an essential, practical insight to the study.

Another important element with regards to interview preparation was the implementation of a pilot interview, strongly recommended by Kvale (2007). The pilot interview was carried out with a free-range egg farmer from the Aberystwyth area. Thanks to this experience the researcher learned how to determine potential limitations, flaws and other weaknesses within the overall interview design. Farmer's valuable notes and comments allowed further revision and preparation to be made prior to the interviews and assisted in the refinement of research questions.

4. Results

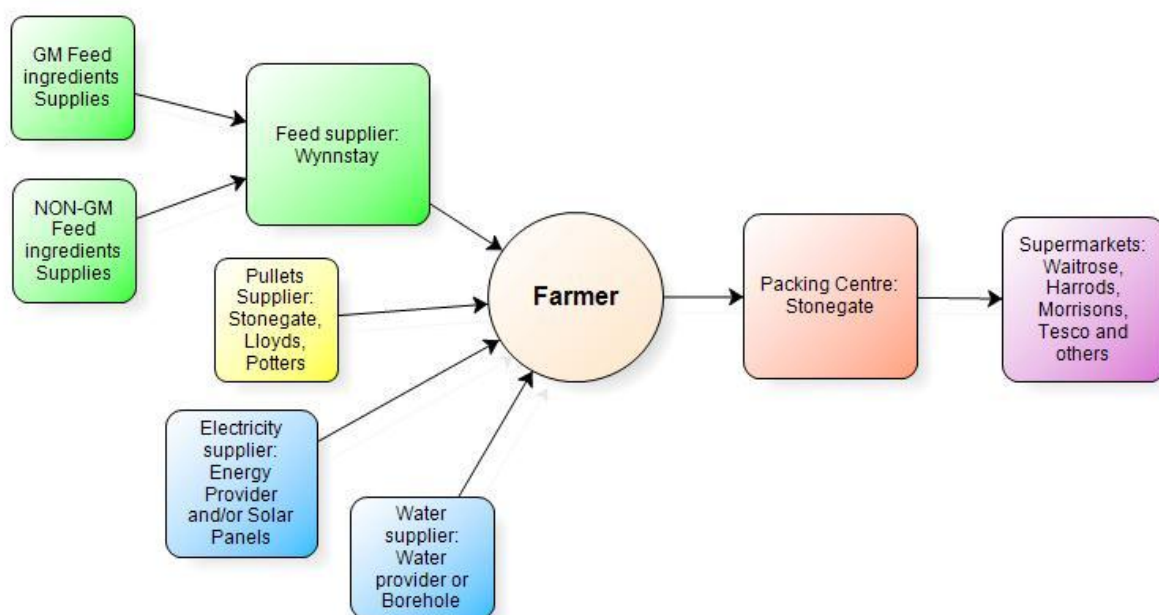
The methodology described in the previous chapter provided the foundation for data gathering and analysis. This chapter is focused on the qualitative data collected from the interviews with the free-range egg farmers and quantitative data obtained from farms' performance spreadsheets that were made available for research.

4.1. Mapping the Egg Supply Chain

There were four main suppliers in the chain: pullets, feed and services (electricity and water), and two main customers: packing centres and supermarkets. For the majority of farmers, pullets were usually supplied by Stonegate, a company that is both a supplier and a customer in this supply chain. While Stonegate has its own rearing houses, the pullets could be also reared by other companies like CFB or Potters. The breeds of birds that farmers used range from speciality Clarence Court breeds like Cotswold Legbars and Burford Browns, which lay blue and dark brown eggs, well-suited for a niche market, to regular free-range breeds laying brown eggs such as Lohmann Brown.

All farmers interviewed sell into the same supply chain. Figure 3 illustrates the Supplier-Farmer-Customer supply chain structure.

FIGURE 3. Simplified model of a Supplier-Farmer-Customer supply chain structure



A linking point of all farmers interviewed is the feed supplier - Wynnstay. It is a well-established company that offers services in the fields of agricultural supply and professional retail. The company's feed production complies with the Universal Feed Assurance Scheme (UFAS), an EU food and feed legislation scheme that guarantees safe and environmentally friendly feed production (AIC, 2014). The rules on the composition and marketing of poultry feed are being drawn up by the Food Standards Agency (FSA), which is responsible for food safety and food hygiene across the UK. Wynnstay provides both GM and non-GM feed rations, however, non-GM raw materials are increasingly hard to source and there is an expectation that non-GM feed may be withdrawn. Table 3 shows typical non-GM and GM feed formulations for free-range layers in the middle of the laying cycle. The company is also certified to produce medicated feed for poultry flocks that require treatment.

| TABLE 3. Non-GM and GM feed formulations | |
|--|-----------------------|
| Source: Wynnstay | |
| Non-GM | GM |
| Oil | Oil |
| Protein | Protein |
| Fibre | Fibre |
| Ash | Ash |
| Efa | Efa |
| Calcium | Calcium |
| Na | Na |
| Mepenz | Mepenz |
| Wheat | Wheat |
| Non GM hypro soya | GM hypro soya |
| Barley | Barley |
| Non-GM maize | GM maize |
| Limestone granules | Limestone granules |
| Sunflower extract | Sunflower extract |
| Non-GM fat | GM fat |
| Monocalcium phosphate | Monocalcium phosphate |
| Layer supplement | Layer supplement |
| Salt | Salt |
| Aliment | Aliment |
| Sodium bicarbonate | Sodium bicarbonate |
| L-lysine | L-lysine |
| L-threonine | L-threonine |

Animal feed plays an important role in the food chain and it has a huge impact on livestock performance and the quality of the products. It must contain all the correct nutrients throughout the lay period as it influences the hen's body weight which in turn affects yolk size, egg weight and eggshell quality. During various laying stages, chickens are assigned different feed diets that are designed by the company's nutritionist to suit their particular needs. Wynnstay company representatives work closely with farmers to provide them with support and advice in the fields of farm management, feed quality and animal performance. While electricity and water suppliers are national providers for the majority of farmers interviewed, some farmers have chosen to use alternative sources. Many have decided to install solar panels on their sheds, which whilst they do not fully substitute for electricity needs, still significantly reduce electricity expenses. Other farmers decided to invest in a borehole, which provides sufficient water supply, but at the same time, has some major disadvantages. The interviewees commented that the maintenance of a borehole can be expensive and very time-consuming. If not supervised and treated properly, a borehole can get infected with bacteria and become an enormous threat to the birds' lives and laying performance. Water is the most important nutrient for hens which means that it must be supplied at good quality all the time. Moreover, water and feed consumption are directly related. If birds stop drinking water, feed consumption drops as well and this is quickly followed by a decline in egg production.

Customers downstream in the supply chain include Stonegate packing centre and various chain-shops and supermarkets in the country. As mentioned before, Stonegate does not only supply pullets but is also responsible for collection and distribution of eggs. The company offers production contracts to independent producers. It buys all the eggs from the farm for an individually agreed and specified period, which are then packed in their packing centre in Wiltshire. Stonegate currently offers several types of production contract, although requirements for producers are usually subject to planning and forecast market demands. Price per dozen varies depending on the size of the flock and the breed type. At the moment, there is a standard flat-rate price per egg for flocks with over sixteen thousand hens, which secures a stable profit margin for the farmer. Farmers with smaller flocks need to negotiate their contracts at every new flock rotation, and a usual market rule applies, the more eggs that are produced, the higher the price per egg can be. Clarence Court is the branch of Stonegate that supplies eggs to niche markets. The speciality blue, white and brown eggs

that are laid by their breeds fulfil a gap in the market for customers who look for extra healthy, GM-free eggs of the finest quality. Contracts for the farmers that produce these eggs are different. The niche market product quality secures a stable contract with Stonegate for a higher price per egg. Therefore, even though these eggs are more expensive to produce, the farmer is still left with a higher profit margin than for a non-premium breed. Stonegate is committed to protect the environment by setting up environmental management controls, procedures and systems that operate at a level above current legislative requirements. They also encourage the farmers to harness the wind and solar power naturally available. On the website² we can read that Stonegate offers farmers advice on the selection and design specification of the housing and can help them to obtain the necessary planning permissions in place to enable a good start for their business.

Supermarkets are the last element of the supply chain. They impose egg prices and therefore have the strongest influence on the rest of the supply chain. The actual market demand for eggs is divided into two streams: colony eggs which are of a regular quality; and free-range, organic and GM-free eggs that represent better quality and higher concern for animal welfare and the environment. The Clarence Court eggs are not only free-range, but also GM-free. They are mainly supplied to Waitrose supermarkets which target customers who are willing to pay a premium for the value added to the eggs. The regular brown eggs are treated as a commodity. Supermarkets do not provide much support for the suppliers of regular eggs as they are easier to source, and therefore, the supplies are also easily replaceable, if required.

4.2. Farmer's Contribution to the Business

In order to set up a business, the independent producer needs to invest in the necessary poultry housing and infrastructure for the enterprise. Any reasonably level, free-draining grassland or arable land is suitable for a hen unit, as the area of land available will govern the number of birds that it is possible to stock on a farm. All new poultry buildings require planning permission from the local authority. Obtaining planning permission can be a complicated and drawn-out process, involving many technical and environmental issues. A farmer can approach these on his/her own, or can ask Stonegate's team for advice on the

² <http://www.stonegate.co.uk/xc>

best ways to approach any planning application submission. The capital costs of poultry enterprises are relatively high, requiring investment in buildings, land, site preparation, ground works, equipment, services and roadways.

It is advantageous if the farmer has some prior stockmanship knowledge, however, experience of poultry husbandry is not absolutely necessary. Stonegate will ensure, through detailed producer manuals and ongoing training, that the learning curve to successful husbandry is kept short. Most producers achieve good production, having started with no experience. The production cycle for free-range egg production is fourteen months, and the enterprise requires management and labour seven days a week during this period. The normal daily routines for a free-range enterprise involves:

- Opening pop holes to ranging area
- Checking birds
- Collecting floor eggs
- Checking ventilation and house temperature
- Checking bird feed and water
- Collecting eggs at least twice daily
- Checking time clocks and all automatic equipment

Other Routines:

- Daily record keeping
- Changing outside paddocks every month
- Keeping grass in paddocks short by cutting or grazing
- Checking perimeter fence
- Laying bait to prevent vermin infestation
- Keeping shed clean and tidy

4.1. Description of the sample

Informants' characteristics are outlined in Table 4 below.

| TABLE 4. Description of the sample | | | | | | | | | | |
|------------------------------------|----------------|--------------------------|-------------|--------------------|----------------|-------------------|---------------------|------------------|---------------------------|------------------|
| Name | Number of hens | Years of poultry farming | Gm, non-Gm | Planning to expand | Clarence Court | Family/Labour | Bank Loan repayment | Solar Panels | Received Grant | Other Farms |
| Farmer 1 | 22000 | 3 | Non-GM feed | No | Yes | Family and labour | In progress | Unassigned | Yes | Sheep |
| Farmer 2 | 6000 | 4 | Non-GM feed | Yes, maybe | Yes | Family | In progress | Planning to have | No | Sheep |
| Farmer 3 | 12000 | 8 | Non-GM feed | Yes | Yes | Family-run | Paid | Unassigned | Applied for, not received | Sheep and Cattle |
| Farmer 4 | 16000 | 4 | GM feed | No | No | Family and labour | In progress | Planning to have | Yes | Sheep and Cattle |
| Farmer 5 | 3000 | 3 | Non-GM feed | Yes | Yes | Family | In progress | Planning to have | No | No |
| Farmer 6 | 16000 | 11 | Non-GM feed | No | Yes | Labour | Paid | Yes | Yes | Turkey and Pigs |
| Farmer 7 | 32000 | 3,5 | Non-GM feed | No | Yes | Family and labour | In progress | Yes | No | Sheep and Cattle |
| Farmer 8 | 16000 | 3 | Non-GM feed | Yes | Yes | Family and labour | In progress | Yes | No | No |
| Farmer 9 | 16000 | 2,5 | Non-GM feed | No | Yes | Family and labour | In progress | Yes | No | Diary and Pigs |
| Farmer 10 | 12000 | 7 | Non-GM feed | No, maybe | Yes | Family-run | Paid | Yes | Unassigned | Sheep and Cattle |

All respondents' farms are located in Wales and, as mentioned earlier, they are customers of Wynnstay. They own small-to-medium sized poultry enterprises, where the biggest farm accounted for over thirty-two thousand hens, and the smallest, a mobile unit, had three thousand hens. The farmers varied in their years of experience in poultry farming, from two and a half up to eleven years of farming. The majority of farms were family-run poultry businesses that permanently or occasionally employed a small number of people. Three out of ten farmers had their bank loans paid back already and the rest were at the beginning or in the middle of the repayment schedule. Nine out of ten interviewed farmers were using GM-free feed for poultry and the majority of them had Clarence Court breeds. Three farmers definitely want to expand their business into a bigger unit. Several of them stated that the poultry units are an addition to the farm that they already had. The majority of farmers have been farming for many years previous to poultry farming and some of them are second generation farmers after their parents, and are planning to hand on their businesses to their children or grandchildren. Seven out of ten farmers have a borehole for water supply and half of them have installed solar panels for an additional supply of electricity for the farm.

4.2. Case characteristics

The interviews highlighted ten main categories that the researcher considered as important and/or were of great importance to the farmers: their motivation to start the business, the economic situation, the efficiency and performance of the farm, animal welfare, the natural environment, the relationships with their suppliers and customers, the marketing of their products as well as their concerns and their perception of various aspects of poultry farming. Several cases in the study involved more than one type of production. For instance, Farmer 1 produced both Clarence Court eggs and regular, brown free-range eggs. As such, comments made by a producer may appear in more than one production system.

4.3. Farmers' motivation to start the business

The interviews showed that farmers had several reasons for opening a free-range egg laying business. One of the main reasons to start a poultry farm was expanding the farm that they already had by adding a poultry unit to it, or transforming an existing unit into a poultry

shed. This was done in order to make their farms more viable, able to support a growing family and improve the quality of life. Farmer 1 said:

“We looked into increasing the number of birds to allow one person to be employed but much to my surprise at the time when we did that, the only viable number of birds was 16,000. (...) so that’s why it has expanded. Solely because of a life-work balance”.

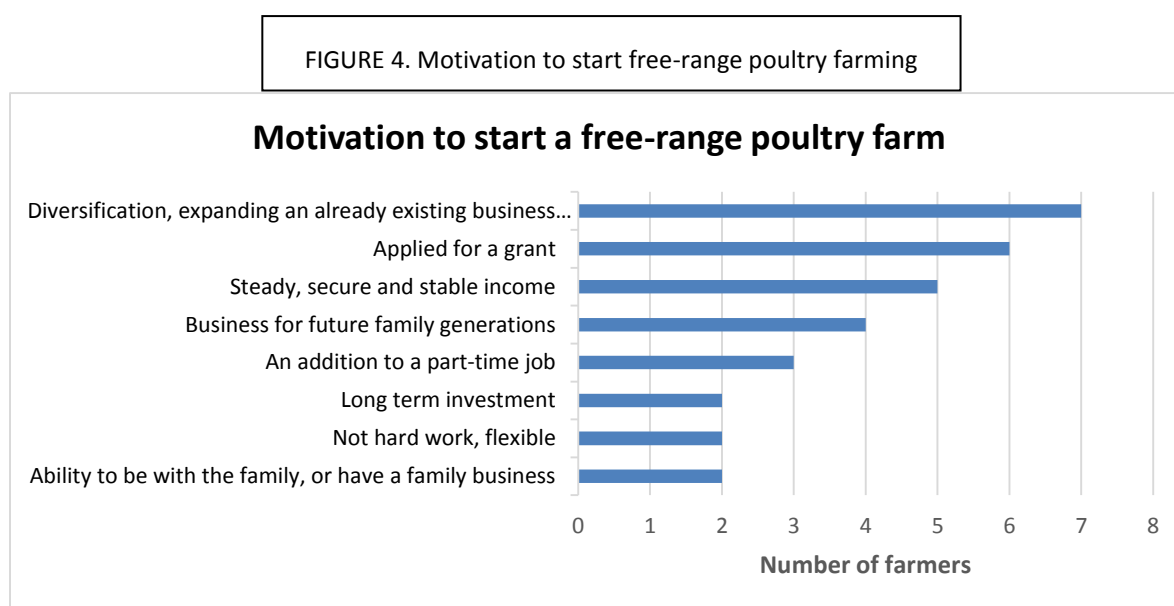
Like in any other profession, poultry farmers are looking for a sensible lifestyle, which may be difficult to achieve taking into consideration that animal farming requires attention seven days per week with no exceptions. The same farmer mentioned, that unlike cattle farming where in the time of need one can easily get a relief milker, it is harder to find a relief poultry husbandry worker. Unless family is involved in the farming, the life-work equilibrium of a small or medium sized poultry farm owner may be difficult to balance.

Half of the farmers interviewed stated that egg poultry farming provided them with a steady and secure income which they would not have been guaranteed with other types of livestock. Some of the respondents mentioned that poultry farming was meant to be a convenient source of additional income to their part-time jobs which would allow them to spend more time with their family. The possibility of being paid a grant also seemed to be a convincing argument towards starting the business. Five out of ten farmers received a small grant allowance, however, one farmer who did apply was not eligible to receive it. Farmer 1 stated that the application process for a grant was very complicated, time-consuming hence they did not manage to finish the application even though they were willing to apply. Taking that into consideration, and adding the difficulty and stress that accompanies the establishment of a new business, it is unlikely that the grant was perceived by the farmer as accessible. Farmers also mentioned that poultry farming is a long-term investment that would pay back in around ten years, and that is why most of them were hoping to pass on the business to future generations of their family. According to some more experienced farmers, poultry farming is relatively easy compared to other types of animal farming, hence they were happy to continue even when they would progress in age.

The downside of the investment was that poultry farming was not subsidised by the government in comparison with other types of animal farming. Moreover, all farmers expressed their concerns about farming animals as susceptible as poultry, where a small,

unexpected circumstance can easily influence the performance of the whole flock. The animal welfare aspect of free-range poultry farming was not as much appreciated by farmers as the economic aspect that it offered.

The numerical visualisation of farmers' responses is shown in Figure 4. It is important to note that one farmer could have more than one reason for starting the business.



4.4. Economic aspects of the business

Regarding the microeconomic analysis of these free-range poultry farms, the majority of farmers stated that their businesses were economically stable, but had minor concerns about the current situation. The interviews discussed aspects such as labour, profitability, competition, bank loans and debt level.

Labour

As previously mentioned, most of the farms in the case study were family-run (nine out of ten). The possibility to hire relatives allowed farmers to remain self-sufficient and helped to make the business more sustainable. Farmers 1, 4 and 10 employed a small number of people, usually 1 person for collecting eggs and a team of people for shed cleaning duties. But as apparent from Table 5, these were farms with flocks large enough to be able to financially support an employed worker. Farmer 6 was completely labour-based, which in the

situation of the other three farmers, would not be profitable, but in this case the bank loan has been already repaid allowing for the hire of additional employee resources.

Profitability

A farm that is viable financially is one that can support farmers' family and provide them with a steady lifestyle. Also, it offsets the capital depreciation of egg buildings and other infrastructures. Another relevant aspect to a farm's financial viability is the regular renewal of the flocks. The interviews showed that in most cases, the animal farming businesses that producers had previous to their egg farming, were not profitable enough to provide the necessary level of income. This was a good reason to look into poultry layers units; an investment big enough to expand the business and at the same time, small enough, when compared with other possible options for farm expansion. Farmer 6 mentioned that expansion of a cattle farm could require millions of pounds to start with, and a big amount of land in order to accommodate the animals. Poultry layers on the other hand need relatively little land and are significantly less expensive. Furthermore, egg farming guaranteed a weekly income, which is a valid determinant for banks in order to meet the eligibility for a business loan. Farmers stated that the level of debts that an individual producer has, makes a huge difference to how profitable they are. Farmer 1 stated that in order to compare farms, it is necessary to take into consideration their personal situations, therefore the only true comparison of how well a flock is performing is to calculate the gross margin over pullets and feed. By acquiring this information, the farmer can estimate how much expenditure is available for the fixed and variable costs like labour, maintenance or loan repayments etc. As every farmer is in a different financial situation, and each one of them has a variety of fixed costs to cover, it is possible that even with a very favourable gross margin, some of them still will not be able to generate profit. The equation for Gross Margin calculation has been included in the next chapter.

The contractual situation with feed supplier and egg packer was different for every case. According to the majority of producers, in order to be profitable with small-scale farming, the eggs needed to supply a niche market. In fact, nine of the ten farmers were producing free-range, GM-free Clarence Court eggs that can be found in supermarkets with a premium price. Only one farmer was producing regular free-range brown eggs. The viable number of chickens at the moment is sixteen thousand, which was the case of six of the interviewed

farmers. This meant that they were able to negotiate lower feed price with Wynnstay, and as the majority of them also had contract with Clarence Court, they were given a flat price per egg. Only the case of Farmer 4 was different; even though this farmer had a bigger flock, they were producing regular GM, free-range eggs. This meant that they were competing on a wider market, where the price per egg was lower and subject to constant changes according to supermarkets' will. Farmer 2, whose flocks did not reach sixteen thousand but was producing niche market eggs, was in a more comfortable position, even though their price per egg was not set and they had to negotiate it every flock. Within that group Farmer 3 and 10 have already repaid their bank loans and their profit was commented to be higher compared to other producers.

As has been mentioned earlier, the financial situation in each case analysed was different, although, general expenses could be included within two groups; fixed costs and variable costs. Fixed costs would be spread across the lifetime of the object or the duration of the service:

- The cost of poultry building(s) and infrastructure. It can be usually calculated for £30 per hen depending on the size of the shed
- Investments (borehole, solar panels)
- Poultry insurance
- Loan repayment
- Debt servicing

Variable costs would have to be repeated every flock and they include:

- Services (electricity and water bill)
- Vet bills
- Medication
- Shed cleaning
- Labour
- Accountancy
- Tax
- Pest control
- Maintenance

Cash flow

Farmer 4 commented that with the low margin levels that poultry farmers have, a continuous cash flow is essential in order to be profitable. However, cash flow can be hard to achieve in free-range poultry farming, as this group of animals has a high vulnerability to external factors. Farmers jointly agreed that free-range chickens are harder to maintain than indoor birds, and a small, unexpected problem like a predator invading the shed can damage the performance of the whole flock overnight. Therefore, cash flow is highly related to farm management and feed quality. Overall, taking into consideration the scale of the investment, the fragility of poultry farming coupled with the low levels of return, means that poultry farming can be considered as a high risk investment. Any interruptions in cash flow can be devastating for the farmer if no alternative income is available.

Competition

According to farmers, there is less competition for Clarence Court eggs than for the regular free-range brown eggs. Nevertheless, Farmer 2 (Clarence Court farmer) expressed concerns about his competitiveness on this niche market. Farmer 2 mentioned that farms are getting bigger and bigger and this is a huge threat for an owner of a smaller flock. The producer interviewed suggested that hens should be kept in smaller units, because not only would it secure the position of small sized farms on the market, but it would also benefit the welfare of the chickens.

Performance

Performance is measured by the results obtained from the production. During the interviews, it was frequently highlighted that key to performance is a good farm management. The production needs to be controlled regularly and problems need to be addressed quickly in order to prevent further complications. The research indicated that those farmers that were relatively new to the poultry business, and in the early phases of repaying back their loans, pay more attention to managing their farms well. All interviewed producers kept a production diary book in which they recorded information about flock performance. They included water usage, hens' mortality and egg production. Farmers then compared the data against breed guide standards and their own experience. This helped them to track changes in the performance of the flock and more easily estimation of the

reason for the drop in production. Reduction in performance was then predominantly treated by specially formulated feed or antibiotics feed that contained more valuable components to help hens to recover quickly. Most, if not all, of the producers expressed their satisfaction with Wynnstay's feed. They rated it as a good quality feed that satisfied their expectations.

Business performance can be also determined by the business growth ratio. Sustainable growth is defined as the annual percentage of increase in revenue that is consistent with a defined financial strategy. The interviews clearly indicated that the producers' revenue is strongly dependent on external factors that are not possible to control such as feed price or egg price. It is believed that because of that there was no mention from any farmers of following a particular predetermined financial strategy. Nevertheless, it is believed that savings could be found in increasing the business efficiency and environmental performance.

Efficiency

Efficiency is a measurement of the results obtained against the resources that have been used. Together with what has been already mentioned on the topic, it would be important to also consider aspects such as farmers' attitude towards efficiency evaluation and benchmarking, current technology on the farm, dealing with losses and managing waste. The majority of farmers were only using the basic spreadsheets to estimate the production efficiency of their farms. Only three farmers interviewed admitted to the use of software or of benchmarking their results across the market. Few expressed an interest in doing so, and the rest were not interested in the topic. One farmer stated that he does not trust decisions made by a computer. The majority of farms have been newly established, and are therefore using modern sorting and packing stations to run their farms, which significantly improves production efficiency as well as reducing environmental impact. Solar panels contribute to lower usage of grid-sourced electricity and thereby reduce overall energy expenses. In all of the cases, poultry manure has either been sold, or spread on their fields, so that no manure has been stored on the farms. This way, even though the manure has still been generating methane, emissions have been kept to a minimum. Lastly, it has been noted that farmers regarded the environmental aspects of their business with an attitude of obligation, rather than as an opportunity for savings.

Concerns and risks

The biggest external concern mentioned by farmers was the feed and egg price. The primary internal concerns was a disruption in the cash flow caused by foxes, rats, disease, water hygiene, fire or intensification of pecking. Most, if not all of the producers, agreed that when it comes to free-ranging poultry, a presence of predators is inevitable, therefore, they need to pay greater attention to fencing and the protection of their flock. Water poisoning is another aspect, that if it gets out of control, can permanently damage the flock performance since water is a main component of poultry diet. According to the company representative and as noted from the interviews, farmers producing niche market eggs expressed less concern for cash flow, whereas GM free-range farmer was strongly concerned.

Animal Welfare

The interviews clearly showed that the reasons behind the farmers' decision to set up a free-range poultry farm was driven more by economic motives than a care for animal welfare. Farmer 6 stated that the reason why they did not invest in cage birds was supported by the fact that at the time they were setting up the business, people were very negative about farming eggs in cages, and they debated whether or not to withdraw the cage systems completely. On the other hand, the same farmer mentioned that a small caged unit would cost several millions pounds, which meant that the investment in free-range units was much more accessible. Nevertheless, some farmers mentioned that they would not be able to farm chickens in the "inhumane, small-sized cages".

An interesting side aspect of the interviews was that all farmers, with no exceptions, agreed that the Defra legislation that introduces a ban on beak trimming is likely to have a disastrous impact on the poultry welfare, and therefore, will have a hugely undesirable influence on the flock performance. Most of the farmers interviewed have observed cannibalistic behaviour in poultry and believe that beak trimming saves chickens from experiencing pain, and farmers from unnecessary trouble.

Natural environment

It has been previously mentioned that farmers have little consideration for the environmental dimensions of their businesses. They were not very concerned about the natural environment whilst starting and running the business. Some of them did install solar

panels on their property, follow environmental schemes or plant trees, however, this was treated rather as an addition to the business and a source of savings than its core idea for environmental protection. The environmental consideration for the majority of farmers was limited to what was needed to be done in order to pass inspections or maintain adequate egg production levels. The farms of this case study were definitely profit-driven, and not environmentally-driven businesses.

Farmers' relationships

There was a clear difference in opinions in the relationship quality expressed between farmers' suppliers and customers, and the level of trust varied in each case.

The opinions about farmers' relationship with pullet suppliers were diverse. Some producers were satisfied with the customer service, expressing that they have been getting good pullets, sufficient attention and good support. Other farmers expressed dissatisfaction about low weight pullets, which resulted in lower performance levels throughout the entire rearing period.

The farmers mostly seemed to agree that their relationship with the feed supplier, Wynnstay, has been very good. Even though they have been concerned about feed prices due to recent increases, they expressed that they have been very satisfied with the company's customer service and reliability. Many of the farmers interviewed have been Wynnstay customers for long years or even family generations. The company has been described as communicative and easy to reach. Nevertheless, as previously mentioned, the farms studied have been appointed by Wynnstay itself, as well as company's representative has been present during all interviews. These aspects may have biased the results.

Stonegate packing centre is both a supplier and a customer in this supply chain. Producers generally described their relationship with Stonegate as good but some admitted to experience difficulties in communicating with the company. They also mentioned that they may have had some problems with pullets in the past, but on the other hand they were very satisfied with the company's reliability in terms of payments.

Supermarkets were commented upon as the most unknown and least communicative chain in the supply. They are known to be setting the egg prices for the market, and some farmers

expressed a desire to know what is going on with egg prices up the supply chain and would feel better if that information became open to them. They said that supermarkets know every aspect influencing a farmer's business, but the farmer knows very little about what supermarkets are guided by in determining egg prices.

Marketing

The majority of farmers producing niche market eggs agreed that Clarence Court was doing an excellent job in marketing those eggs. Nevertheless, Farmer 1 was unimpressed by the fact that their eggs were not marketed as Welsh eggs. On the other hand, the opinion about marketing the brown free-range eggs was fairly negative. Farmers believed that more should be done to advertise those eggs, perhaps in media such as TV or radio.

4.5. Summary

The informal, semi-structured interviews helped to clarify farmers' opinions about various aspects of their business and their profession. The chapter begins with a description of the supply chain studied, which allows a broader understanding of the relationship between farmers, their suppliers and their customers. It then discusses farmers' contributions to their businesses and presents the diverse backgrounds of each case involved in the study. The chapter concludes by outlining twelve key areas contributing to the efficiency of each business, which will be further analysed in the next chapter.

5. Analysis

The quantitative and qualitative data results from the previous chapter provided a foundation for analysis. The initial task was to identify potential opportunities for improving the efficiency of free-range, small to medium egg producing farms, by recognising farmers' perceptions and motivations in running their businesses, as well as investigating the environmental impact of egg farm production. This allowed for an estimation of overall business performance of the free-range egg farms and for the design of production strategies that would aid production activities. Financial decisions are often influenced by non-financial

factors. The social context of the research helped to understand farmer's attitudes in managing their farms according to their own preference and personal situation.

The findings of the study also outline potential areas to be addressed in order to improve the efficiency of the businesses and aid farmers in their day-to-day decision making processes. This will lead to the creation of a farm decision support tool. The analysis and interpretation of data has been carried out in two phases. The first part, which is based on the performance data, deals with a quantitative analysis; the second, which is based on the results of the interviews, is a qualitative interpretation. In addition, two standardised techniques have been applied for the compilation of data, PESTEL and SWOT, which have helped to evaluate the free-range egg businesses in a broader perspective. Taking into consideration the environmental aspects of egg farming, this analysis identified which farm sectors and mitigation methods offer the best opportunity for securing GHG emission and energy usage reductions.

5.1. Efficiency Analysis

Productive efficiency requires all firms to operate using best-practice technological and managerial processes (Black et al, 2004). During the analysis of the interviews, several interesting aspects have been noted. Firstly, the term "efficiency" in those small-to-medium businesses has been approached from a different perspective. For these producers, to be efficient did not have as much to do with being able to produce as many eggs as possible at the lowest average total cost, but rather, about making the business viable enough to support two families and still being able to work regular hours. Taking into consideration that egg farming requires twenty-four hour attention, seven days per week, and for the majority of the interviewees, producing eggs was not the only activity they had, this left them with a very limited time for family and leisure. That is why many farmers have often supported their egg business with the help of their families, or expanded in order to be able to hire additional labour. In these enterprises a replacement farm worker was essential. Consequently, four aspects have been identified which have a major influence on the efficiency of these businesses: farm management (resources and labour), personal situation, price changes and technological advances.

In all cases, good farm management was an essential part of efficient operations. Optimal farm management results in fast growth of small businesses (Withane, 1985) and consists mainly of constant farm supervision, recognising and reacting quickly to threats and changes in poultry behaviour, selecting appropriate recovery treatment, ensuring regular supplies of goods and quality feed, managing labour, and keeping records of egg production, hen mortality and resource usage. Any drop in egg production had to be reacted to immediately. An interesting aspect observed by the company representative was that farmers who have been farming eggs for just a short period of time, have been doing better in managing their farms efficiently, and paying attention to details. Accordingly, those farmers who have been farming for many years and have already paid back their bank loan, exhibit a more relaxed approach to managing their flocks. Therefore, the differences in the attitudes may be caused by the pressure that comes from the loan repayment obligation. Every farmer interviewed was in a different financial and personal situation, and each situation formed and shaped their decisions to a certain level. This process has had a huge impact on their business efficiency. Within the group of farmers, there are individuals that have paid their bank loans already and those that have recently started paying it back a couple of years before. The interviews showed that the latter tended to be more anxious about their economic situation and their future. On the one hand, as the industry novice and holders of the outstanding loan, they generally have got motivation to work harder, but on the other hand, the monetary burden takes away their attention from farm management, and focuses it on economic matters such as contracts, price changes and financial obligations. This preoccupation tends to increase with the smaller sized and unfavourably contracted businesses. These propensities, seemingly trivial, are believed to be one of the crucial factors in the decision-making process. Financial decisions can be induced or compelled by non-financial factors, which include the personality of individuals and the social environment in which decisions are being made (Holden, 2010). The necessity to repay the bank loan inevitably puts pressure on farmers who are obliged to secure the cash flow week after week. Taking into consideration the fact that free-range egg farming is a high-risk investment, and that many factors can change very quickly, farmers are often looking for as much stability as possible. This influences farmers' opinions, incentives and also investment decisions, like selecting equipment, performing the farm processes or putting in place the right contract.

Similarly, price changes for both feed and eggs are an external factor that is hard to control and it is another major aspect that influences the efficiency of egg production. Farmers need to accommodate any prices imposed on them. At the moment, the egg market is still recovering after the recent substantial feed price rise and further price changes in non-GM feed are forecasted due to the soya issues already discussed. The higher the feed price, the more cautious producers become with their spend in order to avoid financial loss. Many producers find security in longer-duration contracts with feed producer or packer, which gives them more confidence and a sense of stability. But not all have flocks large enough to ensure a favourable deal. Technological advancement also plays a crucial role in the efficiency of the farm. Most of the interviewed farmers had newly established sheds that were fully equipped. The condition of the shed, along with its equipment and cleanliness, not only influenced the performance of the layers, but also, the overall performance of the farm. Many of the grants that producers received have been allocated towards packing areas. The packing machines are of a great importance to the egg production, and inevitably lead to greater process efficiency.

5.2. Life Cycle Assessment

As it has already been pointed out in the literature review, the LCA's performed on other farms identified three major environmental burdens arising from production, including GHG emissions, waste emissions and energy usage. The interviews showed that only electricity usage has been monitored regularly on the farms, in a form of a monthly bill. According to the existing law, the businesses researched were not considered as large enough, and hence, are of a minor influence to the environment. They were not appraised on the basis of their GHG and waste emissions, and the environmental policies for this size of free-range farm have not been specified. Therefore, precise data has not been made available for the purpose of this thesis, but general data on the emissions, energy and material usage that was available from other studies has been included in the literature review chapter of this thesis. Overall, egg production was demonstrated to be the least harmful to the environment of all animal farming industries, hence the small and medium sized free-range egg businesses, on which this thesis is focused, can be considered as relatively environmentally efficient. Nevertheless, the scope for the pollution mitigation could be identified in resources management and in applying small, tactical changes to the farm operations. Of course, the

well-known GHG mitigation methods should also be applied such as storing manure only in permitted levels and under a cover. Substituting fossil energy sources for renewable solar or wind power has become widely valued by numerous small producers. Many farmers interviewed installed such solar panels on their sheds for additional electricity supply. This represents a considerable investment, yet is very environmentally friendly and moves towards improving business efficiency. Fossil energy could also be reduced through good management of delivery logistics, for instance, if the farms were placed closer to each other, the egg and feed lorries would have to travel shorter distances, ultimately leading to savings in road fuel.

According to the interviewees, food and animal welfare rules and procedures that apply to poultry farming could be very strict and of the highest standards of all animal farming regulations. However, farmers expressed mixed opinions on this issue. For the majority, the policies have been just an additional requirement to meet in order to fulfil the obligations for free-range poultry farming. Some expressed their view on the strict inspections that were carried out on the farms on a regular basis. Overall, none of the interviewed farmers considered the environmental policies of great importance to the business or worth looking into as an option for long-term savings. This could be considered a disadvantage to the businesses. At the moment, care for the environment is one of the main focuses of the EU. More and more policies and rules are being imposed every year and governments are working towards strengthening consumer confidence in the safety of food (Valletta, 2010). People became increasingly sensitive about their food and the issues surrounding it. Surely, an environmentally-driven egg production process would be appealing to customers who appreciate being informed as to how their food is produced (MacDonald, 2010). Hence, the egg businesses studied should aim to stay as environmentally friendly as possible, and also be able to present their efforts on the product label. It could not only add value to the product but also improve business efficiency in the long run.

5.3. Supply chain

The interviews highlighted two supply chain related issues that were thought to influence the efficiency of farms studied: the overall performance of the supply chain, and farmers' relationships with their suppliers and customers. The performance of this particular supply

chain has been estimated by producers as good. However, the later topic was of great interest to the farmers. There are three companies in the chain that interact with farmers directly; Wynnstay, the feed supplier; Stonegate, the pullet supplier; the packer and the legal contractor; and in one case, the supermarkets. The producers were generally satisfied with how the supply chain was functioning for them. Putting aside the independent economic factors over which farmers have no direct influence, such as price changes or policies, farmers have been mostly satisfied with the service that their suppliers and customers provide. The pullets have been delivered on time, however, difficulty arises when the pullets ordered are underweight. In such a situation, there is not much that a farmer can do, as generally the contracts seem to be more favourable for the suppliers. There are no returns accepted and pullets' suppliers usually allow 10% of weight loss due to transport and adaptation, but it is important to note that a 10% difference in weight can influence the performance of the whole flock. In the worst case scenario, farmers will be left with a weakened flock of pullets starting at a huge disadvantage at the beginning of the production cycle. The pullets will need more time and feed to gain weight to the expected levels, and at the stage when the farmer should start earning money, unforeseen expenses and losses will be experienced. Some flocks will never fully recover and will be significantly less productive. Farmers were, on the other hand, very satisfied with Wynnstay feed deliveries and especially appreciated the extra help and understanding imparted by the lorry drivers. The deliveries were well planned and generally on time so they would never run out of feed. The farmers were also content with feed quality and performance. Stonegate egg collections were done on time and the company was very professional in ensuring that farmers received their payments regularly.

The Economist Intelligence Unit's survey (2008) found that good collaboration between companies is based on trust, and that a rigorous approach to establishing trust as a critical capability in collaboration, enables companies to reap the full benefits of the environment. Farmers' choices and decisions are often made on the basis of trust, and therefore this analysis will compare farmers' opinions and estimate the trust level between particular entities.

It has been observed that the best relationship farmers had, was with their feed supplier, Wynnstay plc. The interviews showed that they have been generally satisfied with the service and a good level of trust has been noted. The companies' poultry representatives appear to

have made a good job in ensuring customer satisfaction. Farmers valued their opinion and appreciated the fact that the company was approachable and stayed in a close contact with them, even when the times have not been propitious. Many stated that they were satisfied with the feed quality, and the service, and had never thought about switching to an alternative feed provider.

The farmers' relationship with Stonegate appeared to be weaker, but slowly improving. The company was perceived as distant and there was a lack of communication between the two parties. Stonegate was believed to be more eager to please supermarkets than farmers, and this was due to ambiguities observed between what was paid to the producers and final egg prices on supermarket shelves. Any major discussions with Stonegate farmers would be made through Wynnstay, as they believed that their individual opinion would not be valued by Stonegate as much as if Wynnstay would represent them. It could be said that Stonegate did not ensure it established good relationships with their producers, which could influence the efficiency of the poultry farms to some extent.

5.4. Performance analysis

As mentioned in the previous chapter, the only true comparison of how well a flock is performing is to calculate the gross margin over pullets and feed. The equation for Gross Margin calculation has been included below.

$$\text{Gross Margin} = \text{Total Revenue from Egg sales} - (\text{Total Feed Cost} + \text{Total Pullet Cost})$$

An analysis of the economic data provided by farmers allowed the researcher to estimate an average margin for free-range eggs with a distinction for GM and Non-GM feed, and Clarence Court and regular pullets. The calculations showed that, at the moment, the gross margin is more beneficial for the Non-GM producers. Even though the Non-GM feed costs are slightly more expensive per tonne than for a GM feed, the Non-GM egg price was also higher, which in comparison with GM egg prices, generated greater revenue. The difference between the gross margins equalled £0.05, being £0.02 per GM egg and £0.07 per Non-GM egg. Precise calculations are included in Appendix C.

The data was calculated on the assumption that 16000 hens produce approximately 12800 eggs per day at 80% of their productivity; there are 58 weeks in a cycle, in 4 of them hens are being fed but do not produce any eggs and the 54 remaining weeks are egg laying weeks. The average feed price for GM feed per tonne was £295 and for Non-GM feed £303; during the cycle birds consumed 730 tons of feed. The average price per pullet for GM eggs was £4.26 and for Non-GM eggs £4.92. The Average price per dozen of GM eggs was £0.91 and £1.50 for Non-GM eggs.

Moreover, in order to indicate the costs of farmers not meeting the expected benchmarks for free-range non-GM egg producers a quantitative data in form of cost implications has been presented below. The examples have been made using the breed standard data and available information from Wynnstay to calculate the financial implications for 5% under and 5% over the expected performance in terms of egg production as well as to indicate the effect of using lesser quality feed.

Egg Production

Assuming that the breed target guide for a laying flock is 303 eggs per bird 5% above this target would be to produce 15 eggs more. The average values per egg is currently 8.3p which would result in £1.24 extra margin per bird. 5% below this target would equate to the above £1.24 less margin.

Feed

The following calculation is a comparison of using the correct quality of feed against a lesser quality feed.

Assuming that 55g of lesser quality feed will be used per bird during laying cycle at £210/tonne that will give £11.55 cost per bird.

In the same way, 48g of correct quality feed used per bird during laying cycle at £225/tonne would equal £10.80 cost per bird.

Even though the price per tonne is less for the 55g usage, using the correct quality of feed at a lower rate saves the farmer 75p per bird.

5.5. Strategies

As mentioned, efficient businesses are able to manufacture products and meet their goals with the minimum of effort, expense or waste. Efficiency is, therefore, a measure of how well the production process is performing. According to a report by CISCO (2014) the capacity of a firm refers to how much a business can produce during a specific period of time. Improving efficiency involves looking for ways to reorganise operations, ensuring employees are qualified and well-trained, and taking measures to decrease wastage. This reduces costs and increases profit margins. Therefore, to remain competitive, businesses must boost operational efficiency wherever possible. It is particularly important for small and medium businesses to operate efficiently, because they often have more limited resources than larger enterprises. The proposed strategies are believed to improve the efficiency, as well as mitigate the environmental footprint, of the egg producing farms studied.

Turnaround Management (TM) techniques were used as a basis for the development of the strategies. Turnaround Management is a process dedicated to renewing a poorly performing corporation, but it can help in any situation where direction, strategy or a general change in operational methods needs to be implemented (Beerli, 2009). TM uses analysis and planning to identify the reasons for failing performances, and therefore, it is an extensively used tool. It involves activity-based costing, root failure causes analysis, and SWOT analysis to determine the weak points of the company and then to re-position it. Since the farms in this study are small businesses that involve few processes, they would require less complex improvement, not a total turnaround, and therefore, only some elements of the TM techniques have been used for the purpose of this research.

KPIs

There are two very different schools of thought as to how performance measurement standards can be improved (Otlay, 1999). One school advocates that traditional financial measurements should be revised and upgraded to make them more relevant and effective within the business environment. The other urges that businesses should disregard financial measures altogether and focus instead on operational parameters. Nevertheless, both agree that no single measure can provide a clear picture of the state of a business. The complexity of managing a business requires managers to be able to evaluate performance in several

areas at once. Similarly, small and large businesses have differing roles in the market, and therefore, the management approach of small businesses will focus on different aspects than those of the large companies. While healthy revenue and profit margins are crucial to the survival of a small business, it is still essential to determine all the factors critical to the success of that business, to measure those metrics and put into place a system for continually improving performance. One of the methods to measure the performance of the egg producing businesses studied would be through the determination and monitoring of Key Performance Indicators. Taking into consideration the previously mentioned schools of thought, it is important to address both the operational and financial indicators.

Within the process of egg production there are a few aspects that play an important role in the overall performance of the business: pullets, feed, labour, animal health/mortality and eggs produced. One of the most important performance indicators of egg farming is the ratio between feed used and eggs produced. The breed guide is essential at this stage in order to benchmark the results. The greater the number of eggs produced at a regular intake of feed, the better the performance. Similarly, it is possible to detect a problem when the egg production dramatically drops or feed intake increases. This way it is possible to assess the quality of the feed as well as hens' well-being. Moreover, the eggs produced are often classified into first-class eggs that have been laid in the nests, and second-class/floor eggs, that have been laid on the floor and are worth less as they are more likely to be contaminated. The percentage of floor eggs needs to be kept to a minimum. If the amount rises, it may indicate that the hens are misbehaving or that the flock has not been supervised properly. Another important measurement is to keep track of the mortality level in the flock thorough the production cycle. Too many hens dying in a short period of time may indicate a problem that needs to be addressed immediately in order to stop further depletion.

One of the financial measurements observed, to be most frequently used by farmers to estimate their performance, is the previously mentioned gross margin over pullets and feed. Calculating this ratio gives the farmer a rough idea of how much money can be spent in other areas of the business and still generate a profit. Surprisingly, most, if not all of the businesses studied, used only this measurement as a main performance indicator. By looking closely, it is clear that there is no visible determinant for the farmers to see if they are running their businesses in a way which actually enhances its value. Small-scale egg farming is very

unpredictable. It deals with a range of variables that can influence the business easily, like the market, the supply chain, and the animals. The financial performance, therefore, is up to a set of external, independently operating factors which demand huge flexibility from farmer, and leave them with a different result every time. It is simply not possible to manage all the financial factors that influence a small egg business. However, ignoring them or relying only on the farm's flexibility, and stretching it to the limit, may have destructive effects on the business. Instead, looking for financial stabilisation would improve the performance. This can be done by controlling the factors that do depend on the farmer, like securing a contract for feed and eggs, which will narrow down the financial risks. The labour input also needs to be measured and kept to a high standard, as this influences the business finance. This can be measured by calculating the amount of eggs packed on a pallet and the time that was needed to complete the task. Setting up KPI will also benefit the performance of the business.

| TABLE 5. Key Performance Indicators | |
|-------------------------------------|--|
| KPI | Measure |
| 1. Profitability – gross margin | Ratio of gross margin over pullets and feed |
| 2. Profitability – net margin | Ratio of gross margin over pullets and feed to fixed costs |
| 3. Feed performance | Ratio of feed used to egg produced |
| 4. Mortality rate | Percentage of dead hens weekly |
| 5. Labour productivity | Ratio of physical hours of labour input to egg produced weekly |
| 6. Egg production performance | Ratio between the number of hens and the amount of eggs they produce weekly expressed in percentage. |

By collecting and organising the factors that are critical for these enterprises, it is possible to find trends emerging from the findings on a regular basis. Table 5 proposes six Key Indicators that are believed to measure best the performance of farms studied. The profitability can be expressed as a gross margin of the profit from egg sales over the cost of pullets and feed. This is an ideal measurement used to stay on track with cash flow, and to provide an overall idea of how the business is performing. However, the drawback is the fact that because of the frequently changing external factors (mostly feed price), it can be measured in detail only

after the end of the production cycle. During the production cycle this indicator can only be estimated approximately. In addition, it does not include the fixed costs that every farmer needs to account for in their budget. The solution to the latter problem would be to calculate the net margin, which is the ratio of the gross margin over fixed costs. But again, it would not be possible to measure specifically the net margin over shorter periods, as the feed prices are only set a few months ahead.

Feed performance is another essential indicator. It measures two very important issues: feed quality and animal well-being. The advantage to this measure is that close observation and record-keeping can assist in identifying trends in feed consumption that can signal potential problems such as disease or pests. On the other hand, by calculating the ratio of feed used to eggs produced, it can be applied as a good indicator of feed quality. Further, most breeding guides include information about the average level of accumulated percentage of hen mortality throughout the production cycle. It would therefore be advisable for farmers to keep records of the spent hens on a daily basis and to compare it to guideline recommendations. However, calculating a weekly mortality percentage would allow farmers to benchmark the results with other farms with similar conditions, if this information would be available.

Labour productivity, on the other hand, reveals several economic indicators, as it offers a dynamic measure of business growth and competitiveness. It is commonly defined as a ratio of output per unit of input (Freeman, 2008); so the number of eggs produced to the total number of hours worked. This key indicator impacts, not only the total output of labour costs, but also capital productivity and various costs incurred by business. Moreover, a high productivity level typically indicates efficient production of goods. A limitation to this indicator is that it reflects, only partially, the productivity of labour in terms of personal capacities of workers or the intensity of their effort.

Lastly, egg production performance is another very important indicator that can be expressed as a ratio between possible egg production and actual number of eggs produced, over a definite period of time. It is an essential method of keeping track of the progress of the business and is commonly used in egg farming. Calculating the percentage of egg production is especially useful when the flock has experienced problems which consequently

lowered hens' performance. It allows the estimation of how much production is required in order to avoid losses. Farmers then can aim towards this goal and design their management and operations accordingly.

SWOT

Small and medium enterprises are confronted with a variety of internal and external forces. As one of the steps in the development of an efficient business, managers can identify these forces which will help business in reaching its full potential. It will allow to survey the different management areas, gain insight, and accordingly undertake appropriate actions. Good performances within a company can be ensured by maintaining correct interaction of business management with its internal and external environment. To operate successfully in this respect, the business should focus its future objectives on its strengths, while preventing and eliminating tendencies related to the companies weaknesses. One should also be familiar with the opportunities and threats resulting from the external environment. The recognition of these four forces, internal strengths and weaknesses, as well as external opportunities and threats, takes place on the basis of a study called a SWOT analysis (Chermack et al, 2007).

For the purpose of this thesis SWOT analysis has been used in order to examine the businesses studied. The strategic approach of the framework enabled the identification of strengths, weaknesses, opportunities and threats deriving from the internal and external environment of the free-range egg farms. It helped to draft a general view of farms management and to identify possible operational weaknesses and served as a basis for improved efficiency strategies proposal. The results are presented in Table below.

| TABLE 6. SWOT Matrix – Analysis of the farms studied | |
|--|---|
| <p>STRENGTHS</p> <ul style="list-style-type: none"> • Exclusive niche market • Certified care for animal welfare • Best quality eggs | <p>WEAKNESSES</p> <ul style="list-style-type: none"> • Lack of communication and trust in the supply chain • Not many grant aids available |
| <p>OPPORTUNITIES</p> <ul style="list-style-type: none"> • Increasing market for free-range eggs • Increasing awareness of healthy food | <p>THREATS</p> <ul style="list-style-type: none"> • Withdrawal of non-GM soybean • Possible introduction of new environmental policies |

Strengths

The research showed that the small and medium sized free-range egg businesses have several advantages over their bigger competitors. Firstly, they are the only possible suppliers of GM-free eggs for Clarence Court, as the company requires the flocks to be kept in relatively small numbers as well as preselects the breeds to acquire specific types of eggs that are considered to be top quality products in the market. This gives those businesses an exclusive access to the niche market and a higher price per sold egg. Secondly, unlike bigger companies, the small farms have a simple business structure which, if well managed, should allow easier and faster inside communication and better control of on-farm processes. Lastly, every farmer interviewed had the knowledge and experience that is required for successful management of a farm, and most of them are motivated to perform the best that they can, in order to achieve their financial goals. Therefore, the hens can be found to be living in good conditions and eggs to be of the finest quality which not only is an important aspect for food hygiene, but as well a strong environmental and welfare friendly marketing position for egg sale. The eggs are certified by the Lion Mark code of practice which ensures that one is receiving eggs produced to the highest standards of food safety.

Weaknesses

The findings suggest that, the biggest weakness for the egg businesses studied was a lack of communication and trust down the supply chain. The relationships between farmers and their customers seemed to be formal and insecure and resulted in limited conversations between the parties, lack of trust and confidence. Moreover, farmers were found to be reluctant to use more advanced methods of monitoring the performance of their farms, and were irregular and rather superficial with benchmarking. They preferred to rely only on their experience, which may, or may not, always be accurate. Lastly, poultry farming is known to be the agricultural sector where not much government funding is available to support the businesses. The interviews showed, that the available funding was limited and perceived to be hard to obtain, which was believed to be a significant discouragement for running the business.

Opportunities

The opportunities for free-range egg farmers could be found in environmental care and well-considered business decisions for the future. Care for the environment is one of the major concerns of European Union nowadays, therefore addressing environmental issues beforehand may give the businesses a strategic advantage. Furthermore, as showed the Eurobarometer study, the market for free-range GM-free eggs is increasing as more and more customers is willing to pay extra for eggs that come from environmentally friendly farms that care for animal welfare. This could be considered as a strong marketing asset that meets the needs of the niche market, and if the trend continues, the share of non GM, free-range eggs in the egg market may increase.

Threats

The research showed that the external threats are mostly of a political and legal origin, from which the most important threat for the businesses at the moment would be the withdrawal of non-GM soybean production. This would deprive farmers of the niche market value of their product and significantly reduce their profit. A situation like that would be highly undesirable, however very much probable. In addition, more and more environmental policies are being introduced every year and it is possible that in future years they will also

affect small businesses. This may put the farms in a difficult position in which change of farm management operations would be required, and additional equipment expenses may be needed.

Recommendations: actions towards efficiency

Taking into consideration all of the above, recognising the advantages and issues in the internal and external environment of the farms studied allowed to explore areas for new initiatives and obtain the following strategies:

The unstable situation and possible withdrawal of non-GM soya is by far the most threatening issue for the businesses studied as they are securing their profit mainly on the non-GM quality of the eggs and the high-end, free-range class of the products. They are expecting to spend more for breeding the birds but get bigger profit margin in return. If one of these crucial differentiators is lost, the profit margin, depending on the scale of media coverage and supermarkets' will, would be expected to drop more or less significantly. In order to mitigate the disturbing effects of this circumstances, meticulous tracking of the non-GM soya situation on the market would be required. Farmers studied are aware of the problem and are being regularly informed by the feed company of the situation. If withdrawal was the case, Wynstay's and Stonegates' knowledge and support would be essential for the farmers so that the feed transformation process could go smoothly. Nevertheless, switching to regular egg production might be an alternative option for these farmers, as one of them have already decided to do this.

Furthermore, it would be beneficial for the businesses if more funding was available for egg businesses. The funding possibilities at the moment are very limited and the access to them is difficult, therefore it would be advisable for the government to look into this issue and start a farm investment program by proposing alternative grant options that would be more accessible to the farmers. With the opportunities seen in the growing demand for environmental protection, there is a scope for the grants to not only provide the support for the economic part of the business but, as well, encourage farmers to invest into the environmental aspects of the business. Helping to make strategic environmental decisions at an early stage could not only be a good move for the future, but could also become an interesting marketing asset for the products, maybe even partly replacing the non-GM soya

advantages. Also, additional savings could be found by investing in the use of renewable energy on the farms. On the other hand, farmers are often using bank services to help themselves to start their new business or to expand. The government could aid them greatly by establishing loan guarantee programs. They would be less costly for farmers than grant aids and will assure an emergency cover for farmers that are investing in this high-risk business.

In addition, the lack of trust for other members of the supply chain indicates a need for communication improvement. Good communication is a base for consistent cooperation and affects some decision making processes. This issue will be further explored in the next paragraph.

Finally, in the fourth place, taking into consideration that egg farming is a high risk investment, careful and precise production monitoring would help to reduce unnecessary losses. Farmers would be encouraged to involve computer software to follow and analyse their operations. A decision support tool that may aid with this process will be proposed further in this chapter.

Retrenchment Strategy

To improve the efficiency of the businesses studied, it is important to look into a wide-range of short-term actions that would reduce financial losses, to stabilise them and work against the problems that contributed to poorer performance. It is all about maximising the return on investment. The first step could be to transform the cost structure across the business to obtain cost leadership and gain competitive advantage. Farmers can often secure a better deal for feed and eggs simply by stepping out and talking to the supplier about their options. It has been observed that some farmers can be very reserved in their relationships with the suppliers and customers. Addressing the problem head-on, being open about it, and by exercising some negotiation skills, is likely to result in a better deal for the business. This way, the producers can turn the supply chain into a source of competitive advantage.

Effective and interactive collaboration between employees, partners, suppliers and customers is a great method to boost efficiency whilst also reducing costs. Communication and a good level of trust is key, nonetheless, barriers within the supply chain have been observed. Its structure, along a top-to-bottom hierarchy, is composed of a series of

independent divisions competing against each other which is unlikely to create a healthy medium for sharing information. Instead, it would be encouraged to create an open-door culture where producers are not afraid to provide suggestions and feedback to their suppliers and customers, and vice versa. Better communication will increase the efficiency of the supply chain and ensure that all relevant parties have access to the information they need to perform. Organising special meetings, where farmers can speak for themselves, with the confidence that their opinion and insight will be valued and their concerns addressed, will make interactions more effective. Even when problems cannot be solved immediately, or are part-solved, this is likely to build up farmers' morale and improve the relationship and trust level between the parties. One advantage of being an SME is the ability to react quicker than larger competitors, however, to achieve this, it is essential to provide farmers with secure and consistent access to information.

Increasing productivity in the workplace can also improve the efficiency of the farms. Productivity measures the relationship between inputs into the production process and the resultant outputs. The most commonly used measure is labour productivity. If the worker could pack a pallet in half an hour less than usual, this would increase the unit cost. As the number of eggs collected by the packer is the same every day, this method will not generate savings by increasing the sales revenue, but by saving up work time that could be devoted for other farm management activities such as shed inspections. Additionally, it would be good for the business to create an energy management programme. Businesses should conduct an audit of the machinery and the electrical systems to ensure they are energy efficient and running at full capacity. They should analyse their current use of energy and resources and investigate how to improve energy performance. It would be essential to set goals for more efficient use of energy and put the plan into action.

Every company should aim to achieve operational excellence in the most critical processes to deliver high quality service at a competitive cost. A business process is a set of steps or tasks that the farmer and his/her co-workers use repeatedly to produce eggs, reach specific goals, and provide value to the customer and supplier (Jeston, 2006). When processes work well, they can significantly improve efficiency, productivity and customer satisfaction. However, processes that do not work can cause shortage, delays, resources wastage and financial loss. Every business needs to improve most processes after some period of time. New goals, new policies and changes in the business environment can all cause established processes to

become inefficient or outdated. Therefore, every so often it is important to revise the efficiency of the operations by analysing and benchmarking the KPIs. The farmers need to ensure that all formal and informal processes are streamlined. When everyone follows a well-tested set of steps, there are fewer errors and delays, there is less duplicated effort and staff and customers feel more satisfied. For those farmers that hire labour, when improving a process, it is best to work with the people who are directly involved. Their ideas may reveal new approaches, and also, they are more likely to buy into change if they have been involved at an early stage. Farmers should adopt a continuous improvement approach. Small improvements made regularly will ensure that the process stays relevant and efficient.

Renewal Strategy

During the renewal, businesses should focus on long-term actions which are predicted to end in a successful managerial performance. This thesis has analysed the existing structures within the farms and the supply chain. The examination showed that the farm's structure was composed of one farmer, or a couple, that employed members of their own family and/or trained external staff. Consequently, there were two types of very basic structures within the farms that do not require any closure or division. Instead, it would be advisable for the farmers to develop a workflow chart to outline individual responsibilities, and review it on a daily or weekly basis, to ensure every aspect is being covered. As the majority of observation is done internally, a good level of information exchange should be maintained by staff. Moreover, farmers should be provided with ongoing training to ensure they are well-versed and updated on the best practices in the field.

Whilst it makes good business sense to have reliable incumbent suppliers, over time they tend to increase the prices for their products and services, hence all suppliers should be reviewed on a regular basis. A commonly used strategy is to switch suppliers, but since the options for alternative feed and packing suppliers are limited, this puts the farmers in the most vulnerable position in the supply chain. Nevertheless, the same principles should be applied to business utilities suppliers, such as telecommunications, water and energy, where there is a wider range of providers available. This is likely to generate a small amount of savings per month which can contribute to significant savings over a longer period of time. Just ten pounds per month will generate £1,200 in savings over ten years.

In addition, it would be advantageous to farmers to keep up to date with the situation in the egg market as a whole. Effective measurement lays the groundwork for future plans, so keeping track of the condition of the market is the way to improve effort. Monitoring market tendencies and customer perceptions will keep farmers up to date and avert surprises. Farmers should prepare themselves for any major change in the market that is forecasted, particularly the withdrawal of non-GM soybean crops. As the majority of farms base their income on the GM-free qualities of the eggs they produce, this could result in a dramatic drop in their profit margin.

For businesses like egg farming, that involve a high investment risk, it would be very beneficial for the producers to create an accident and disaster recovery plan. Efficient companies prepare for disasters and ensure that they have the resources and information they need to react decisively. Farmers should analyse potential risks to the business and minimise or eliminate them. They should identify the company's most valuable assets, and prepare contingency plans to protect those assets from any risks that cannot be eliminated, such as natural disasters. This might involve having an evacuation plan or a litigation readiness plan.

Lastly, farmers would be advised to benchmark their productivity against market guidelines more often, as well as their previous production results. They could use free online tools or computer software. This way, they could monitor their flock performance regularly, spot potential problems before they come to light, and respond to them more effectively. Software can present data in chart or table format, which makes interpretation simpler and more straightforward than some of the commonly used analysis methods such as spreadsheets and forms.

5.6. Future Possibilities and Options

The majority of farmers are planning to keep their businesses for more than ten years in order to pay back bank loans and start receiving profit from their investment. It is therefore important to place the strategies for improving efficiency of such farms in an economic context by taking into account the feed and poultry situation in the wider market. This would help to estimate future possibilities for poultry farming and ensure the optimum development of those businesses. This thesis uses PESTEL framework in order to examine the

current political, economic, social, technological, environmental and legal situation in the British poultry market and around the world.

The current political situation can be influential for the future of poultry farming. The European Union has established minimum standards governing the welfare of farmed animals and the introduction of the regulation for welfare labelling in the UK has enabled customers to know exactly where eggs were sourced and how they were farmed. The same type of EU labelling could be soon introduced for environmental protection and GHG emission. At the moment, the environmental regulations only apply to intensive poultry farms with more than forty thousand hens (DEFRA, 2013), but if the number of small and medium free-range farms continue to grow, the regulations may also be imposed on this economic sector. It would therefore be beneficial for the egg producers to consider these political tendencies in advance. Moreover, the political situation in the Ukraine has impacted globally on poultry trade, as Russia has banned poultry imports from the US, EU, Canada, Australia and Norway, for twelve months. However, this situation is not expected to influence the UK as much as it is influencing the US, because the UK mostly supplies eggs to British and European markets (Ferdman, 2014).

The issue that is of a great importance to the farmers at the moment is the fact that the British government is considering to ban beak trimming on hens (Parliament, 2014). All the farmers studied unanimously believe that this would have a disastrous effect on their farming. Beak trimming has minimised hens' innate cannibalistic tendencies for years, and such a ban would bring great losses to farmers and hinder business efficiency. New techniques of farming would have to be introduced, but according to farmers, nothing equally as effective has been discovered to date.

Furthermore, an increasing number of free-range small and medium sized poultry egg farms are being opened every year. Farming poultry is a good option for diversification. One of the most important economic factors at the moment that is likely to influence the niche egg market is the total withdrawal of non-GM soybean. Non-GM soybean is becoming increasingly hard to source which is shifting its price globally. It is likely that it will stop being profitable to source non-GM soya in the near future, which will strongly impact upon the egg

market. Waitrose, the main British vendor of non-GM eggs is already preparing its customers for this highly probable situation³.

Another economic factor is that Avian Influenza still considered a threat after its recent spread in 2013. The new bird flu, which has emerged in China, has been able to transmit easily and has caused severe pneumonia in humans. In such circumstances, restrictions on live poultry markets will have to be imposed in order to curb the number of infections.

In addition, the already mentioned EU welfare labelling regulations is changing people's perceptions about egg production systems. Customers are increasingly aware of what they are getting. As mentioned earlier, a considerable amount of British nationals think that the current level of hens' welfare is poor and should be improved. Such opinions are slowly shifting consumer decisions towards buying free-range eggs. This could be considered both an economic and a social factor. Society expects humane treatment of animals, hence the demand for free-range and organic eggs is growing. However, this is not the only reason why people choose these eggs. In the market where everything is mass produced, free-range eggs are considered more natural and healthy. This social factor could shape the future of the egg market.

Technology is always the fastest changing discipline in any area. At the moment, the multi-tier sheds are becoming more and more popular among free-range egg farmers, because they allow more chickens to be kept on a smaller area of land. The egg sorting and packing machines are also of a great help to a farmer who can limit the number of employees.

For many, the environmental aspect is possibly the most important aspect of poultry farming at the moment. The European Union is intending to mitigate all types of environmental pollution in the coming years by carefully monitoring businesses and their operations and enforcing environmental regulations. The main focus is being placed on GHG emissions, waste disposal and energy usage.

Lastly, from a legal point of view, there are many different rules and codes of practice for poultry farmers. Among the most important quality control organisations and schemes in the UK is DEFRA, Freedom Food and the Lion Quality Code. DEFRA is responsible for environmental protection and food production standards in agriculture. Freedom Food is a farm assurance scheme that regulates the conditions for animal welfare and is controlled by the Royal Society for the Prevention of Cruelty to Animals (RSPCA). The Lion Quality Code is a

³ http://www.waitrose.com/home/inspiration/about_waitrose/the_waitrose_way/gm.html

mark that can be stamped onto eggs by producers who are signed up to its Lion Quality Code of Practice that imposes vaccination against Salmonella and places certain welfare, feeding, traceability and freshness standards upon producers. It is possible that in the future even more rules will be applied to poultry farming, if certain laws will come into work.

5.7. Summary and Discussion

The objective of this chapter was to examine the processes involved in running a small or medium sized egg laying poultry farm and estimate the level to which they influence the overall efficiency of the poultry businesses studied.

For the producers, the efficiency of their businesses was interconnected with its viability in their day-to-day life. Even though every farmer had a different financial situation, one of the most important factors that they were concerned about was finance and loan repayment. Their attitudes towards managing their farms tended to vary between those who had already paid back their loans and those who were in the beginning of the process.

Furthermore, views of the complexity of free-range egg farming varied by the size of the farm. In general, smaller size egg producers expressed greater concerns over the future of their businesses. The amount of birds they have does not allow them to enjoy the comfort of financial stability and to adequately negotiate prices with their suppliers and customers.

Similar to the findings from Piboonrungraj (2012), the results from this study suggest that trust is an essential component of a good supply chain collaboration, and that good relationships between the suppliers and customers can improve business performance. Lastly, five strategies for improving the efficiency of farms studies has been proposed, and each one of them used a different approach to analyse the processes involved in running those businesses.

6. Conclusion and Recommendations

The objective of this study was to define the major environmental impacts of free-range egg producing farms as well as to lay out basic strategies for improving the efficiency of free-range, non-GM egg farms under investigation.

The first part of this thesis focuses on the environmental impacts of free-range egg production. The growing potential of the egg industry needs to be addressed with caution and knowledge so that the environment is not further degraded and the productivity is increased in a sustainable manner. Previously conducted research showed that the environmental impacts of egg production are largely related to the efficiency of resource use of a system. The free-range egg production systems were proven to be less efficient than the cage systems, and therefore, had higher environmental impacts. The major differentiator was the fact that free-range birds use more feed per kilogram of eggs produced compared to cage bird. Amongst the methods researched by scientists to mitigate the environmental footprint of feed would be improving its efficiency by designing sustainable diets, using alternative, more environmentally friendly ingredients, or reducing the inclusion of imported soya. The amount of water and energy used for egg production is believed to be a minor value in comparison to other UK industries. The environmental performance of products and processes has also become a key issue to consumers who are increasingly factoring welfare considerations into their purchases. Due to this value conflict a majority of UK customers are likely to buy eggs from free-range farms.

The second part of this thesis explored business and sociological dimensions of a particular egg supply chain by evaluating its performance and proposing strategies for improving efficiency. It allowed the analysis of farmers' relationships with Wynnstay Group Plc and Stonegate which presented a fresh, outside perspective on the management of the supply chain. The results of this study indicate that the most important area for the layer poultry farmers under investigation is farm management and that is where the strategies for improving the efficiency and reducing the environmental footprint should be primarily focused. The knowledge acquired has been used to create the below prioritised list of recommendations that is believed to help improve the efficiency of free-range, non-GM egg farming by addressing the major issues that have been discovered during the research.

List of Recommendations:

1. *Consistent monitoring of KPIs.* Farmers could spot efficiency flaws by using the Key Performance Indicators proposed in this thesis and benchmarking their results frequently. Using them would help in maximising feed utilisation, minimising variable costs, managing labour, managing overall equipment effectiveness and implementing continuous improvement programs.
2. *Improving communication and interconnectedness between the supply-chain members* is another aspect which is likely to bring great benefits to the efficiency of the businesses studied. It would be encouraged to organise meetings where farmers could speak for themselves, with the confidence that their opinion and insight will be valued and their concerns addressed. This is likely to build up farmers' morale and improve the relationship between the parties. Moreover, it would be of a great benefit to the farmers to get informed better about the reasons behind decisions than have been made on the supplier and customer end of the chain. Involving farmers into the decision-making process would improve the trust level between the parties.
3. *Pursuing environmental strategies as an option for a long-term savings.* There is considerable potential for egg farming in Wales, especially in the niche market where the eggs are being produced in free-range and animal friendly conditions with the aim of improving environmental performance for the future. All these aspects are of a high importance for today's customers who are looking for businesses to remain as natural and harmless as possible. The scope for further development of high quality and environmentally benign egg production will provide alternative opportunities for farmers, either as a major enterprise or diversification strategy, to improve farm profitability and generate additional labour demand in the open countryside.
4. *Improving the accessibility of grants and supporting farmers with loan guarantees.* It would be beneficial for the businesses if more funding was available to support their efforts. The government could look into creating farm investment programs and proposing alternative grant options that would be more accessible to the farmers than the ones existing at the moment. Moreover, the government could aid farmers by establishing loan guarantee programs as they would be less costly than grant aids and will assure an emergency cover for these high-risk businesses.
5. *Using a software tool that could aid farm management and benchmarking.* As it has

been previously mentioned, the most efficient changes would be made if addressing the farm management itself, which is the only area where farmers have full control of the operations. As outlined in the analysis, the process of on-farm decision making has been mostly based on farmers' extensive experience and valued advice from outside experts. In order to improve the control over the decision-making process, this thesis develops a proposal for a Decision Management Support Tool (DMST) which could be made available to farmers as a system for record-keeping and financial management in one simple-to-use software package. This software will be explained in more details in the next paragraph.

6.1. Decision Support System

There are numerous types of software that could be used by the egg industry in order to manage farm processes. Independent companies usually issue software that is available initially as a free trial and is followed by monthly plans based on the size of operations. Costs range from £12 a month for a standard plan to £75 a month for a premium user⁴. A variety of tools are available to offer help with a range of activities such as contract management, cost accounting, crop management, customer management, calculating payables, receivables and depreciation, financial management, inventory management, livestock management and tax management. However, the major drawback to this software is that it is created for the purpose of large enterprises and for crop as well as animal farming. This means that the user would most certainly require a substantial amount of time to navigate the programme and a prior training. More importantly, the software may approach some farming concepts too broadly and may not be specifically adapted for the needs of egg farming, which can result in approaching certain aspects too generally. Some companies already involved in poultry farming, offer farmers help with farm management in a form of Microsoft Office spreadsheets. Nevertheless, this tool can also be complex in its operation.

The owners of the small and medium farms studied mostly cannot afford sophisticated software that is often designed to support extensive farming operations. Therefore a different solution is needed. Unlike the currently released programmes, the tool proposed by this thesis would target smaller sized poultry farms and would be available for free. Since

⁴ <http://www.agrivi.com/pricing/>

it has been observed that poultry farmers tend to be occupied at all times, it would serve against its purpose to present a tool which they would not have time to learn how to use. Instead, the software should be designed for basic computer users, as an easy to operate programme, that would encourage farmers to spend an additional ten minutes a day to control their operations. Depending on farmers' needs, the tool would allow them to manage their processes, facilitate record-keeping and monitor their production and environmental footprint efficiency. It would aim to prevent problems by identifying and monitoring critical control points in the production and would give farmers an informed perspective on their current situation. It would also help to identify corrective actions for potential deficiencies or suggest future possibilities. The software would address the most important aspects of day-to-day farm management and therefore would help with evaluating business progress and future opportunities. There are four aspects that the tool would address, and they are based on the previously mentioned KPIs.

6. Income calculator

It is essential for every farmer to know how much income they are able to produce in order to make informed decisions. The income calculator would calculate the gross and net margin, taking into consideration egg price, feed price and performance level. The egg price would depend on the contract that the farmer has agreed with the packer. The feed price, on the other hand, is a regularly changing value that also depends on the farmer's individual agreement with the feed company. The net margin would have to include all the fixed costs that can be allocated to egg production and this would also be individual for every case.

7. Performance measure

Performance is one of the most important measures of on-farm operations. It would be expressed in percentage and calculated by taking into consideration egg production and mortality level of hens on the timescale of production cycle. Those values could be benchmarked against the breed manual guidelines, the farm's own previous performance or between different egg producing farms. This tool would become particularly helpful when the flock did not perform on an anticipated level through the production cycle and unexpected problems appeared during the process. The significant drop in performance, and therefore income, could be then recuperated by maintaining performance on a certain level.

8. Loan pay back

This is an option where a farmer could insert the necessary data and see their progress with respect to repayment of the bank loan. It is certainly one of the efficiency factors which farmers are most concerned about, but at the same time, because every farmer has a different financial situation, there would be numerous scenarios that the software would have to be programmed to consider. It would have to support all the bank loan repayment schemes that are available for the farmers on the market at the moment, and those from the past, and further research would need to be conducted in the area of available bank finance packages for poultry units. The repayment level would be calculated as a ratio of the amount borrowed, and what is left to be repaid within a set amount of time, including the bank charges. As the decision-making process is both affected by the financial and emotional factors (Holden, 2010), a quick and easy way to check the progress of paying back the loan could inevitably provide farmers less financial stress and a clearer perspective of the future.

9. GHG calculator

Taking into consideration the fact that the farms researched have no information about their GHG emissions, since it is not yet being measured for small and medium farms, the tool would, at the present time, only be able to include some guidelines and advice on how to manage farm operations in order to mitigate harmful environmental emissions. This option, however, may become useful in the future for measuring the farm's impact on the environment. Calculating emissions is a multi-step process. A precise tool can only be developed after careful study of quality control issues and activity data (Green House Gas Protocol, 2014). The emissions would be calculated as a the ratio of carbon dioxide emissions to total greenhouse gas emissions (including carbon dioxide, methane and nitrous oxide, all expressed as carbon dioxide equivalents) for litres of gasoline, kilowatt-hours of electricity and other on-farm emissions. The software would also offer useful advice on environmental schemes and grants available for small scale producers, which would have to be regularly updated.

Establishing the software on KPIs would ensure that the tool is managing the key operations and focusing on what is really important for the farmer. The progress of this tool would depend on further study in the area of economics, accounting and environmental emissions.

6.2. Limitations of the Study and Suggestions for Future Research

This thesis contributes to the literature on the environmental and economic efficiency of free-range egg production by highlighting the role of farmers' views and opinions in shaping their attitudes towards managing their egg producing businesses. Whilst it has identified important differences in attitudes amongst owners of free-range egg farms, the findings of the study also suggest various areas for future research, as there are academic challenges that arise from several major sources.

Acquisition of environmental data

The first concerns the limited time for acquisition and analysis of appropriate economic and technical production data that are amenable for use as proxies, with respect to emissions and other life-cycle environmental impacts. Time and resources were not sufficient enough to collect and study the environmental data directly from the chosen sample, hence, a more general approach has been adopted using existing studies on the environmental impact of egg production.

Acquisition of economic data

The second involves gaining trust to allow for collaboration between the various interests represented in the egg supply chain, to share additional data and to incorporate qualitative perspectives on operational issues and other inter-company relations which need to be developed to allow for integrated cross-chain improvements in performance to occur. The access to farmers' economic data has been very restricted, which made the economic analysis considerably more difficult to perform. The efficiency analysis have been therefore only approached from a general perspective using the limited data that was available and calculating the cost implications of over and underperformance in areas such as egg production and feed.

The research suffered from a lack of quantitative data for each farm studied. Due to the limited access to economic information it was not possible to obtain and analyse the economic data on manure produced, labour costs, recent investments and hen production costs for every farm. Unfortunately, the data on feed costs, annual egg production, costs per pullet and mortality rates for each farm was not complete, therefore a precise data

comparison required for performance analysis was not possible. For this reason the researcher had to undertake a more qualitative approach for efficiency analysis, which significantly limited the findings of the research regarding the efficiency of farms studied. A future research could address this issue by approaching the problem quantitatively and doing a detailed data compilation which then would lead to appropriate conclusions.

Research sample

The results from this study were generated from a relatively small number of cases that may not have represented the true composition of Welsh free-range egg farming agricultural landscape. Moreover, this thesis investigates a niche area of free-range non-GM eggs, which limits the extrapolations that can be made in to other forms of egg production. Though all efforts have been made to ensure that selected cases offer a representative view on the different aspects of free-range egg production, the ability to generalise from the results of the study is limited. Future research utilising a survey method could reduce the uncertainty and improve the ability to generalise from such a study of free-range egg farmers' views.

Similarly, as previously mentioned, the researcher did not select the farms studied personally; they were chosen and contacted by the collaborating business on the basis of pre-agreed with the researcher conditions. A bias might have occurred if only 'well collaborating' farms have been chosen to be contacted by the researcher. This could question the reliability of farmers' opinion about Wynnstay and affect the clarity of some of the findings for this research. It would be desired for any future research to include randomly selected farms that would not be influenced by an external party. Due to the nature of the study and funding, this research did not allow for an alternative arrangement and the researcher was mindful of this fact. However, it has been ensured that the company was fully aware of the disadvantages that would follow in case of obtaining biased results.

Practical implementation

Finally, the limited time of this project did not allow for practical implementation of the knowledge that has been establish, hence this also can be an opportunity for future research.

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APPENDICES

Appendix A

Open interview questions

1. Can you tell me why did you set up this business and how?
2. What support was available to you and were there any obstacles?
3. Could you describe your business and how well does it operate?
4. Are you planning to make any improvements? Haven you got the resources?
5. How do you manage your business and how do you evaluate its performance?
6. Thinking about the economic side of your business what are the benefits and downsides? Overall do you find your business model profitable?
7. What is the structure of your business? Is the business family run?
8. Please could you talk about your environmental policies?
9. Do you think your product is market well to your customers?
10. Please describe your working relations with your suppliers and your customers?

Appendix B

Software Analysis Tool

NVIVO

NVIVO is a qualitative data analysis computer software that has been designed for analysing unstructured data. It facilitates the work with rich texts, where deep levels of analysis on small or large volumes of data are required.

The screenshot shows the NVIVO software interface. The top menu bar includes File, Home, Create, External Data, Analyze, Query, Explore, Layout, and View. Below the menu is a ribbon with various tools. The left sidebar shows a tree view with 'Nodes' selected. The main area displays a table of nodes and their associated data.

| Name | Sources | References | Created On | Created By | Modified On | Modified By |
|------------------------------------|---------|------------|------------------|------------|------------------|-------------|
| Animal Welfare | 3 | 3 | 2014-07-19 21:39 | PK | 2014-07-20 23:52 | PK |
| Business structure | 10 | 32 | 2014-07-19 12:15 | PK | 2014-07-23 09:12 | PK |
| Commercial packages | 2 | 3 | 2014-07-19 19:53 | PK | 2014-07-22 12:18 | PK |
| Concerns | 7 | 20 | 2014-07-20 23:07 | PK | 2014-07-22 16:08 | PK |
| Economy | 19 | 29 | 2014-07-19 21:38 | PK | 2014-08-03 14:40 | PK |
| Efficiency and performance | 9 | 24 | 2014-07-19 22:28 | PK | 2014-08-05 12:54 | PK |
| Farmers relationships | 4 | 6 | 2014-07-19 19:03 | PK | 2014-07-20 23:57 | PK |
| Farmers' perception of egg farming | 0 | 0 | 2014-07-19 12:22 | PK | 2014-07-19 19:03 | PK |
| Interview questions | 0 | 0 | 2014-07-18 17:05 | PK | 2014-07-18 17:05 | PK |
| Investments, improvements | 7 | 11 | 2014-07-19 12:39 | PK | 2014-07-22 14:51 | PK |

| A: Name | B: Sex | C: Number of ... | D: Years of p... | E: Gm, non-Gm | F: Planning to | G: Clarence C... | H: Number of ... | I: Bank Loan r... |
|---------|--------|------------------|------------------|----------------|----------------|------------------|-------------------|-------------------|
| | Female | 22000.00 | 3.00 | Not Applicable | No | Yes | Family and labour | In progress |
| | Male | 6000.00 | 4.00 | NON-GM feed | Yes, maybe | Yes | Unassigned | In progress |
| | Male | 12000.00 | 8.00 | NON-GM feed | Yes | Yes | Family-run | Paid |
| | Female | 16000.00 | 4.00 | GM feed | No | No | Family and labour | In progress |
| | Female | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| | Female | 3000.00 | 3.00 | NON-GM feed | Yes | Yes | Unassigned | In progress |
| | Female | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| | Male | 16000.00 | 11.00 | NON-GM feed | No | Unassigned | Labour | Paid |
| | Male | 32000.00 | 3.50 | NON-GM feed | No | Yes | Family and labour | In progress |
| | Male | 16000.00 | 3.00 | NON-GM feed | Yes | Unassigned | Unassigned | In progress |
| | Male | 16000.00 | 2.50 | NON-GM feed | No | Unassigned | Unassigned | In progress |
| | Male | 12000.00 | 7.00 | NON-GM feed | No, maybe | Yes | Family-run | Paid |

The screenshot shows the NVIVO software interface with a search result. The 'Nodes' list on the left shows 'Efficiency and performance' selected. The main area displays a search result for the query 'And why did you chose this ventilation? Was is because of the planning permission?'. The result shows a snippet of text from a source, followed by a reference to 'Reference 5 - 3.95% Coverage'.

And why did you chose this ventilation? Was is because of the planning permission?

No, it's less to go wrong. Motors of the fans they gotta break some time, and if we got a power cut, forced ventilation is gonna go straight away but this is still ok. The light go off but.. it's a lot less to go wrong. That's why we went for flat deck not multi-tier as well.

Reference 5 - 3.95% Coverage

And why multi-tier wouldn't be good?

Appendix C

Calculations

Assumption: 16000 hens produce 12800 eggs per day at 80% of their productivity.

| Data | |
|-------------------------|----------|
| Weeks in a cycle | 58 |
| Feeding weeks | 58 |
| egg laying weeks | 54 |
| Feed consumption | 730 tons |
| GM feed per tonne | £295 |
| Non-GM feed per tonne | £303 |
| GM pullet price | £4.26 |
| Non-GM pullet price | £4.92 |
| GM eggs price per dozen | £0.91 |
| Non-GM eggs | £1.50 |

$$\text{Gross Margin} = \text{Total Revenue from Egg sales} - (\text{Total Feed Cost} + \text{Total Pullet Cost})$$

Gross margin for GM eggs

Number of eggs produced:

$$4868400 \div 12 = 403200 \times £0.91 = £366912$$

Egg sales:

$$12800 \times 7 \times 54 = 4838400$$

Feed consumed:

$$730 \times £295 = £215350$$

Pullets costs:

$$12800 \times £4.26 = £54528$$

Feed per egg:

$$£215350 \div 4838400 = £0.045$$

Gross margin:

$$£366912 - (£215350 + 54528) = £366912 - 269878 = 97034$$

Gross margin per egg:

$$£97034 \div 4838400 = £0.02$$

Gross margin for non-GM eggs

Number of eggs produced:

$$4868400 \div 12 = 403200 \times £1.50 = £604800$$

Egg sales:

$$12800 \times 7 \times 54 = 4838400$$

Feed consumed:

$$730 \times £303 = £221190$$

Pullets costs:

$$12800 \times £4.92 = £62976$$

Feed per egg:

$$£221190 \div 4838400 = £0.046$$

Gross margin:

$$£604800 - (£221190 + 62976) = £604800 - 284166 = £320634$$

Gross margin per egg:

$$£320634 \div 4838400 = £0.07$$

The difference between the gross margins equalled £0.05, being £0.02 per GM egg and £0.07 per Non-GM egg.